ENTIAT

Subbasin Plan

Prepared for the Northwest Power & Conservation Council

Entiat Subbasin Plan

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1 Introduction

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2.1 Purpose and Scope

National Oceanographic and Atmospheric Administration (NOAA) Fisheries (formerly the National Marine Fisheries Service (NMFS)) released a biological opinion (BiOp) on the operation of the Federal Columbia River Power System (FCRPS). This system is operated by the U.S. Bureau of Reclamation (BOR), the Bonneville Power Administration (BPA), and the U.S. Army Corps of Engineers (ACOE). The FCRPS operation has impacts on six fish species listed in 1999, under the Endangered Species Act (ESA), as threatened or endangered. The FCRPS BiOp proposed a set of Reasonable and Prudent Alternatives (RPA) for the operation and configuration of hydropower facilities on the Columbia River to mitigate impacts to the survival of listed juvenile and adult salmonids in the Columbia River basin. As part of the 2000 FCRPS BiOp, NOAA Fisheries advised the aforementioned federal agencies that, in addition to hydropower facility modifications, offsite mitigation for habitat, hatcheries and harvest would be required to avoid jeopardy. It also established performance standards and schedules to monitor the success of mitigation measures.

In order to help meet offsite ESA obligations under the 2000 FCRPS BiOp, the Northwest Power and Conservation Council's (NPCC) Fish and Wildlife Program collaborated with other federal caucus members to develop the subbasin planning process. When complete, subbasin plans will identify and prioritize actions needed to recover listed salmonids in tributary habitats within the Columbia River basin, and guide the expenditure of BPA revenues on these offsite mitigation projects. The Qualitative Habitat Assessment methodology is being utilized in the development of subbasin plans in order to compare the ecological effects of proposed actions, and determine what benefit is likely from each restoration alternative.

The three main parts of a subbasin plan are:

The Assessment - A subbasin assessment is a technical analysis to determine the biological potential of each subbasin and the opportunities for restoration. It describes the existing and historic environmental resources, conditions and characteristics within the subbasin.

The Inventory - The inventory includes information on fish and wildlife protection, restoration and artificial production activities and management plans within the subbasin.

The Management Plan - The management plan is the heart of the subbasin plan. It includes a vision for the subbasin, biological objectives, and strategies. The management plan addresses a 10-15 year planning horizon.

2.2 Planning Approach

In 1993 members of the Chelan County Conservation District (CCCD), Natural Resource Conservation Service (NRCS) and the US Forest Service Entiat Ranger District (USFS Entiat RD) met with the Entiat Chamber of Commerce and secured its support for a watershed planning effort for the Entiat and Mad River watersheds. The Chamber initiated a search for local citizens interested in initiating and participating in the watershed study.

Watershed planning under the Watershed Planning Act (WPA) may be initiated for a subbasin only with the concurrence of: all counties within the subbasin; the largest city or town within the subbasin; and the water supply utility obtaining the largest quantity of water from the subbasin (Chapter 90.82.060 RCW). Recognizing that the voluntary emphasis and locally-led focus of the WPA paralleled the existing Entiat Coordinated Resources Management Plan (CRMP) group's structure and collaborative nature, the CCCD and USFS worked with Chelan County, the City of Entiat, and the Entiat Irrigation District to initiate the watershed planning process for the Entiat subbasin (WRIA 46; see Chapter 173-500 WAC) in 1998. The invitation to become initiating governments was also extended to the Confederated Tribes and Bands of the Yakama Nation (Yakama Nation) and the Confederated Tribes and Bands of the Colville Nation (Colville Nation). Although neither tribe accepted this offer, the Yakama Nation did agree to actively participate in the process.

The initiating governments designated the CCCD as the lead agency responsible for developing the subbasin planning process and scope of work; convening representation from a wide range of water resource interests; coordinating watershed plan development; and applying for and managing watershed planning grant funds. In 1998 the CRMP group led a successful effort to secure funding from the Washington Department of Ecology (WDOE) to develop a management plan for the Entiat subbasin (WRIA 46) and continue the group's efforts under the framework outlined in the act. With support of the initiating governments and the CCCD, stakeholders and participants that were already part of the Entiat CRMP group reorganized to become the Entiat WRIA Planning Unit (EWPU). Additional interest groups, such as the Yakama Nation and Chelan County PUD, also joined and broadened the makeup of the EWPU (CCCD 2004).

Over the past ten years, many individuals have contributed towards the watershed vision that is captured in the Final Draft Entiat Watershed Plan (January 2004). Because of the similarities in content and intent of the NPCC Subbasin Planning and State 2514 Watershed Planning, most of the materials developed for the Entiat Watershed Plan and approved by the Entiat Planning Unit is the basis for the Entiat Subbasin Management Plan contained in this document. This document was developed under the purview of the Entiat Planning Unit and associated Technical Teams and the implementation of the recommended Management Strategies will continue to be guided within this public forum.

2.3 Entiat Watershed Planning Unit Vision Statement and Goals

To voluntarily bring people together in a collaborative setting to improve communication, reduce conflicts, address problems, reach consensus and implement actions to improve coordinated natural resource management on private and public lands in the Entiat subbasin. The vision is to implement the locally developed, science based subbasin management plan using watershed specific information ultimately leading towards compliance with the federal Endangered Species Act (ESA) and Clean Water Act (CWA). Our end products will reflect a balance between existing natural resources and human uses and will capitalize on opportunities to improve these values.

Specific goals to move us forward towards this vision under the Watershed Planning Act are as follows:

- Optimize quantity and quality of water to achieve a balance between natural resources and human use both current and projected
- Provide for coexistence of people, fish and wildlife while sustaining lifestyles through planned community growth, and maintaining and/or improving habitats
- No avoidable human-caused mortality of State and Federal Threatened, Endangered and Candidate species
- Develop and implement an adaptive action plan to address priority issues, emphasizing local customs, culture and economic stability in balance with natural resources. All actions will comply with existing laws and regulations. However, changes to existing laws and regulations will be recommended as needed to attain our common vision and avoid one-size-fits-all solutions

Recognizing the significance of the roles of limiting factors outside of the watershed and natural events within the watershed, the long-term goal is to have the Entiat River's existing and future habitats contribute to the recovery of listed species and to eventually provide harvestable and sustainable populations of fishes and other aquatic resources.

Since 1993, landowner members of the CRMP Group/EWPU have always insisted that good science be applied to the collection and interpretation of information for all resource elements of concern. They hope that through the continued use of good science, the mission and goals of the group will be met, and with landowner cooperation during implementation, regulating agencies may not find it necessary to apply one-size-fits-all regulations to achieve their management objectives for the Entiat subbasin (CCCD 2004).

2.4 Subbasin Planning Goals and Ecological Objectives

As stated above, the Entiat Planning Units vision is to implement a subbasin management plan that will reflect a balance between existing natural resources and human uses and will capitalize on opportunities to improve these values. Listed below are specific goals adopted for the purposes of subbasin planning. Accompanying each of these goals are ecological objectives. Progress in achieving these objectives will be monitored to ensure accomplishment of the Planning Units overall Vision.

Goal 1. Maintain existing high quality habitat and the native fish and wildlife populations inhabiting these areas

Goal 2. Enhance or restore degraded areas, and return natural ecosystem functions to the subbasin

- Maintain, enhance, or restore the distribution, diversity, and complexity of watershed and landscape scale features to ensure protection of the aquatic systems to which species, populations and communities are uniquely adapted
- Maintain, enhance, or restore biological diversity associated with native species and ecosystems
- Maintain, enhance, or restore sustainable and productive range and upland vegetative communities so as to promote watershed health and native ecological diversity
- Maintain, enhance, or restore significant culturally related natural resources
- Maintain, enhance, or restore unique habitats associated with riparian corridors along streams and in the upland environments
- Maintain, enhance, or restore the spatial and temporal connectivity within and between watersheds. Included are the drainage network connections, floodplains, wetlands, upslope areas, headwater tributaries, and intact refugia
- Maintain, enhance, or restore natural stream flow regimes per temporal and spatial patterns
- Maintain, enhance, or restore habitat to support well-distributed populations of native plant, and riparian-dependent species, including habitat necessary for sustaining salmonids at critical life history stages of spawning, rearing and migration
- Maintain, enhance, or restore properly functioning floodplain and riparian conditions
- Maintain, enhance, or restore the water quality necessary to support healthy riparian, aquatic, and wetland ecosystems

Goal 3. Restore, maintain, or enhance fish and wildlife populations to sustainable and harvestable levels, while protecting biological integrity and the genetic diversity of the species

- Maintain or increase abundance of native fish and wildlife species to a level where populations can be harvested and can be sustained through natural reproduction and productivity

- Maintain or rebuild distribution of native fish and wildlife populations to perpetuate spatial structure, life history diversity and genetic diversity
- Maintain and/or restore performance (productivity, abundance and life history diversity) of wild, indigenous populations in a manner that maintains or enhances genetic similarity to naturally producing populations (Artificial propagation is considered a relatively short term measure and is not intended to replace naturally producing populations over the longer term.)

Goal 4. Increase public involvement, knowledge and appreciation for the protection, restoration and enhancement of fish and wildlife resources

- Provide scientific basis for protecting aquatic ecosystems and enhance open, public planning processes for sustainable resource management
- Develop tools and processes to increase greater public involvement in accurately assessing the responses in fish and wildlife populations and their habitats to specific strategies recommended and undertaken
- Assess current and future water supply and community needs and develop a long-term strategy for sustainable community growth and efficient water conservation
- Inform, educate and involve landowners, recreationists and the general public about the need to protect, restore and enhance fish and wildlife resources

Goal 5. Improve fish and wildlife management, regulation and enforcement, public involvement and government incentives and funding to maintain and restore natural ecosystems and the species they support

- Increase effectiveness of decision-making and management of fish and wildlife populations and their habitats
- Make decision-making about and management of fish, wildlife populations and their habitats populations more effective
- Strengthen plans and regulations to restore and maintain habitat that supports healthy, harvestable populations of fish
- Use incentives and government funding to support the protection and restoration of fish, wildlife and their habitats
- Build citizen support and involvement in restoration, conservation and enhancement of fish and wildlife habitat

Goal 6. Improve coordination for long-term monitoring of fish and wildlife population and habitat and develop the required institutional infrastructure to better insure consistency and efficiency with other local, tribal, state and federal monitoring protocols

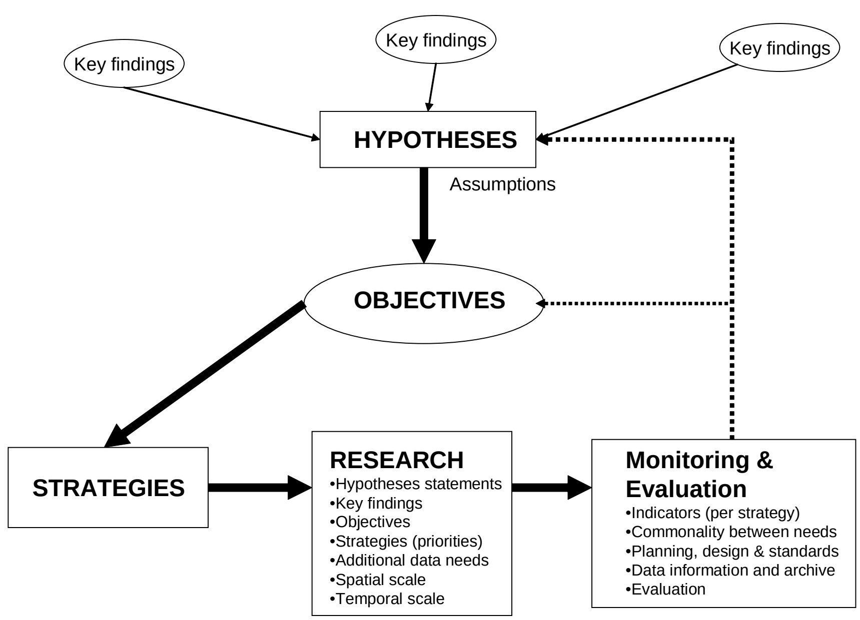
- Develop and employ a trend monitoring program based on remotely-sensed data obtained from sources such as aerial photography or satellite imagery

- Develop and implement a long-term statistically-based monitoring program to evaluate the status of fish populations and habitat (This requires probability-based statistical site selection procedures and establishment of standard protocols and data collection methods.)
- Implement experimental research monitoring at selected locations to establish the underlying causes for the changes in habitat and population indicators

2.5 Logic Path and Documentation of the Subbasin Plan

Of primary interest to the Entiat Subbasin Plan is the logic, or rational that supports the recommendations of the Management Plan. The fundamental premise in the development of this Plan is to identify 1) what habitat conditions have been most effected by developments in the last 200 years, 2) how have important species responded to these changes, and 3) what can local resource managers and citizens do to maintain and enhance these and other important terrestrial and aquatic populations and ecosystems (Figure 1).

Figure 1. Logic diagram



There are six sections contained within this subbasin plan. All sections are closely related but can be read and understood independent of the others. Below is a brief summary of the content and intent behind each of the six sections.

2.5.1 Subbasin Overview

The subbasin overview provides a coarse overview of the subbasin with respect to the Columbia Cascade Province and with the key environmental features within the Entiat Subbasin. This information is simply descriptive in nature and is meant to help orient the unfamiliar reader with the subbasin. This section also provides a Scientific Conceptual Foundation, which describes the underlying premises of how Subbasin Planners view and interpret ecologic health and population responses within the subbasin and relevant to the larger Columbia Basin region as a whole. This information provides the framework of how Assessment information is interpreted and Management Recommendations are developed.

2.5.2 Assessment

The Assessment is descriptive information that addresses Terrestrial and Aquatic considerations separately. Essentially all of the information used in the Assessment exists in published literature, or was derived from Technical Subcommittee meetings, assembled periodically for the development of this subbasin plan.

The terrestrial assessment is based upon focal habitats. These habitats are considered sensitive and/or vulnerable to changes in environmental conditions, especially from rural or urban developments. Representative species that have a direct association are identified for each of the focal habitats.

For aquatic considerations, focal species were selected based upon a) cultural significance, b) fulfillment of a critical ecologic function, c) serves as an indicator to environmental health, d) are locally significant, and/or e) are a federally listed species. Focal species are seen as a "canary in the coal mine", such that their populations' health is a cumulative result of many environmental attributes. If these populations remain healthy, it is reasonable to conclude that the overall environmental condition and function is reasonably healthy. Focal species are described with an emphasis on their life history strategies, their relationship to various habitats, and their population characteristics and status.

A significant component of the Assessment is a description of habitat and ecologic conditions within the Entiat Subbasin. For the purposes of this document, the subbasin was dissected into four separate "Assessment Units", based primarily upon major watersheds contained within the subbasin. Each Assessment Unit is described with regards to its overall Watershed Condition, Riparian and Floodplain Condition, Stream Channel Condition, Water Quality, Water Quantity (flow) and Ecological Condition. These topics are inclusive to key and measurable habitat attributes important to survival and productivity of the focal species. Specific habitat attributes are evaluated and summarized in the Ecosystem Diagnosis and Treatment which primarily focused on streams available for anadromous fish use. The EDT model was used to evaluate habitat conditions for spring and late-run chinook salmon. Evaluation of other streams and focal populations was based upon existing Biologic Assessments developed by the US Forest Service for federal projects on publicly managed lands, and approved by the US Fish and Wildlife Service and NOAA Fisheries.

Each discussion of the Assessment Unit concludes with a brief discussion about important Environmental/Population Relationships, Areas of Special Interest, Limiting Factors (for focal species production) and key Data Gaps. These topics provide a synthesis of the Assessment Unit and highlight habitat conditions and functional relationships that are considered in the determination of recommended Management Strategies.

2.5.3 Inventory

The Inventory is a list of on-the-ground projects that have been implemented in the recent past, using the last five-years as a guideline. The simple purpose of the Inventory is to indicate if recently implemented projects are consistent with the needs identified by the Subbasin

Assessment. Comparing the projects from the Inventory with the habitat needs is a "Gap Analysis" which serves as the conclusion to this section.

2.5.4 Synthesis and Interpretation

The Synthesis and Interpretation focuses primarily upon aquatic resources and is the most complex section within the Subbasin Plan. The key elements within section are the 1) Key Habitat /Population Relationships, 2) Determination of Restoration Priorities, 3) Key Findings 4) Hypothesis Statements 5) Reference Conditions 6) Near-term Opportunities and 7) Determination of Restoration Priorities.

Key Habitat and Population Relationships provides a brief synthesis of the environment from the eyes of the focal fish species. This material identifies general types of actions that should be considered to enhance the productivity of these populations.

Determination of Restoration Priorities is taken from the Biologic Strategy to Protect and Restore Salmonid Habitat in the Upper Columbia Region (2004) developed by the Regional Technical Team and adopted by the Upper Columbia Salmon Recovery Board. This information describes the basic criteria for determining priorities in species distribution across the landscape, and provides guidance in prioritization of protection and restoration activities. Important to note here is that this logic does not specifically prioritize or discount any potential project or activity to benefit fish and wildlife resources, rather it provides guidance in overall funding considerations.

The Key Findings and Hypothesis Statements are organized in a similar manner as the Assessment. Key habitat attributes that limit focal species production within the subbasin and an identification of attributes that remain in good ecological condition are summarized. This summary is a synthesis of the Assessment for each of the key habitat attributes. Hypothesis statements are provided for those habitat attributes that are considered to be impaired and are particularly important to the overall ecology of the subbasin. Statements are provided that estimate species response if these conditions could be improved to a natural range of variation (or the desired future condition, as discussed in the Management Plan). These discussions provide the basis for establishing priority actions within the Management Plan and Monitoring strategy.

Reference Conditions are provided that relate the presumed past, existing and potential future environmental conditions to potential fish performance. A reference condition is a benchmark from which habitat changes and/or population performance can be compared over time. Reference conditions are qualitative in nature and intended to provide context for identifying potential policy considerations over a relatively large time (year 2050) and geographic (subbasin) scale.

Near-Term Opportunities are identified in this section. The management actions recommended here could be implemented and/or could be substantially advanced within a 10-year time period if managers are successful in developing an aggressive implementation strategy and secure appropriate funding. Because these actions are generally feasible within the foreseeable future, it is appropriate to identify a measurable level of accomplishment that would signal a highly successful implementation program.

2.5.5 Management Plan

There are five key areas discussed within the Management Plan, the 1) Vision, 2) Objectives, 3) Management Strategies, 4) Consistency with the Endangered Species and Act and Clean Water Act and future 5) Research needs. For consistency and ease of use, the Objectives, Management Strategies and Research needs all are organized in a similar manner as the Subbasin Assessment.

The Vision provides the basic context and direction for the Management Plan. The Vision statement is provided from the Entiat Planning Unit, assembled under the direction of the Washington State Watershed Planning Act.

The Objectives describe the fundamental elements for habitat improvements in a quantifiable manner. Each of the Objective statements is organized by Assessment Unit and key environmental attribute, consistent with the Assessment.

Following the Objectives, specific Management Strategies are recommended for each of the key habitat attributes. These recommendation provide general direction that should be considered when identifying specific habitat enhancement or restoration activities for each of the Assessment Units

A brief statement is included here addressing the relationship between the Management Plan and the Endangered Species Act and the Clean Water Act. The Management Plan, consistent with the goals and objectives of this Subbasin Plan is designed to support the intent of each of these federal Acts.

Concluding the Management Plan, information is provided designed to guide future Research activities within the Subbasin. These statements carefully integrate the biologic objectives, key findings and hypothesis statements described in other portions of this document.

2.5.6 Monitoring and Adaptive Management

Over the past two years, the Regional Technical Team of the Upper Columbia Region has been actively involved in the development of a large scale, long-term monitoring strategy. To date, the Monitoring Strategy is based upon efforts at the Columbia Cascade Provincial scale. Provided appropriate funding levels, it is envisioned that monitoring will be implemented as described, consistent with other subbasin within the Province.

This monitoring strategy is designed to be consistent with ongoing Federal and State direction and will focus considerable attention to three key levels of monitoring: implementation, effectiveness and validation. Consistent with the ISAB (2003) recommendations, the Entiat Monitoring Strategy will (with an appropriate level of funding) 1) contain a trend monitoring program based upon remotely-sensed data obtained from sources such as aerial photography and/or satellite imagery, 2) develop and implement a long-term statistical monitoring program to evaluate the status of fish populations and habitat (his requires probabilistic (statistical) site selection procedures and establishment of common (standard) protocols and data collection methods), and 3) implement experimental research monitoring at selected locations to establish the underlying causes for the changes in habitat and population indicators.

2.6 Synopsis of Key Findings

Key Findings are concise statements/determinations about environmental attributes found to have a relatively high importance to the focal species existence within the Assessment Unit. These statements describe habitat conditions that are functioning properly as well as those that have been altered or degraded to the point that they limit the ability for the focal species to thrive or exist within the Assessment Unit. Key Findings are first described for Terrestrial and then for Aquatic considerations.

2.6.1 Summary of Key Findings: Terrestrial

The terrestrial assessment viewed the subbasin from a perspective of key and major vegetative communities. Three community types were chosen as focal habitat for this evaluation, ponderosa pine, shrub steppe and riparian ecosystems. Within each of these focal habitats, representative species that are directly associated with these vegetative communities are identified and will be monitored.

Factors Affecting Ponderosa Pine Habitat

- Timber harvesting has reduced the amount of old growth forest and associated large diameter trees and snags.
- Urban and residential development has contributed to loss and degradation of properly functioning ecosystems.
- Fire suppression/exclusion has contributed towards habitat degradation, particularly declines in characteristic herbaceous and shrub understory from increased density of small shade-tolerant trees. High risk of loss of remaining ponderosa pine overstories from stand-replacing fires due to high fuel loads in densely stocked understories.
- Overgrazing has resulted in lack of recruitment of sapling trees, particularly pines.
- Invasion of exotic plants has altered understory conditions and increased fuel loads.
- Fragmentation of remaining tracts has negatively impacted species with large area requirements.
- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and may be subject to high levels of human disturbance.

Factors Affecting Shrubsteppe Habitat

- Degradation of habitat from intensive grazing and invasion of exotic plant species.
- Fire management, either suppression or over-use, and wildfires.
- Invasion and seeding of crested wheatgrass and other introduced plant species which reduces wildlife habitat quality and/or availability.

- Loss and reduction of cryptogamic crusts, which help maintain the ecological integrity of shrub-steppe/grassland communities.
- Human disturbance during breeding/nesting season, parasitism.

Factors Affecting Riparian Wetland Habitat

- Habitat degradation from livestock overgrazing which can widen channels, raise water temperatures, reduce understory cover, etc.
- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and be subject to high levels of human disturbance.

2.6.2 Summary of Key Findings: Aquatic

Spring chinook

Spring chinook production in the Entiat River could increase if habitat problems within the lower basin were rectified. Preservation of quality spawning and rearing habitat in the Middle Entiat AU is important to maintain naturally reproducing populations. Increases of off channel habitat and riparian areas in the lower Entiat River would increase potential rearing habitat and life history diversity. Creating or restoring habitat will increase spring chinook productivity by a modest degree, and increase the spatial and potential life history diversity within the Entiat River.

Late-run chinook

Late-run chinook production in the Entiat River could increase if habitat problems within the lower river were corrected. Increases of off channel habitat and riparian areas in the lower Entiat River would increase productivity by increasing potential rearing, adult holding habitat, and genetic, spatial, and life history diversity.

Steelhead trout

Steelhead production in the Entiat River could increase if habitat problems within the lower basin were rectified. Preservation of quality spawning and rearing habitat in the Mad and Middle Entiat AU is important to maintain naturally reproducing populations. Increases of off channel habitat and riparian areas in the lower Entiat River would increase potential rearing habitat and life history diversity. Creating or restoring habitat will increase steelhead productivity by a modest degree, and increase the spatial and potential life history diversity within the Entiat River.

Bull trout

Bull trout production in the Entiat River Basin could increase if habitat problems were rectified. Increases of off channel habitat and riparian areas in the lower Entiat River, would increase potential rearing and adult holding habitat and life history diversity. While creating or restoring habitat may not increase overall bull trout production by a significant degree, it does increase the spatial and potential genetic diversity of bull trout in the Entiat River.

Bull trout are more sensitive than other species to habitat degradation. Water quality requirements for bull trout require the preservation and restoration of high functioning habitat. Processes that affect temperature, sediment load and connectivity from lower quality (feeding areas) to higher quality (spawning and initial rearing areas) should all be considered when trying to increase overall production of bull trout.

Westslope cutthroat trout

Westslope cutthroat trout are known to exist throughout most of the high elevation streams within the Entiat subbasin. There are concerns about the status of this species due to genetic introgression (especially with introduced rainbow trout), competition with non-native species (brook trout), depressed and fragmented populations or stocks, and loss of migratory life histories. Information addressing population abundance, trend and distribution is lacking.

Pacific lamprey

Pacific lamprey still exist in the Entiat system, but the abundance and distribution is mostly unknown. Due to the declining status of this species, and the lack of information a relatively high level of effort to monitor and enhance these populations are recommended.

Coho salmon

Coho salmon were extirpated from the Entiat River. Coho re-introduction into the Entiat River is being considered by fishery co-managers. Implemented of this work would likely proceed with relatively low levels of artificial production during a feasibility phase. Feasibility investigations would occur over several generations of returning fish (approximately 10-years).

2.7 Summary of Restoration and Conservation Measures: Terrestrial

2.7.1 Ponderosa Pine

Goal: Provide sufficient quantity and quality ponderosa pine habitats to support the diversity of wildlife as represented by sustainable focal species populations.

Habitat Objective 1: Determine the necessary amount, quality, and juxtaposition of ponderosa pine habitats by the year 2008.

Habitat Objective 2: Based on findings of Objective 1, provide biological and social conservation measures to sustain focal species populations and habitats by 2010.

Habitat Objective 3: Maintain and/or enhance habitat function (i.e., focal habitat attributes) by improving silvicultural practices, fire management, weed control, livestock grazing practices, and road management in existing and restored ponderosa pine habitat.

Biological Objective 1: Determine population status of white-headed woodpecker, flammulated owl, and pygmy nuthatch by 2008.

Biological Objective 2: Within the framework of the focal species population status determinations, inventory other ponderosa pine obligate populations to test assumption of the umbrella species concept for conservation of other ponderosa pine obligates.

2.7.2 Shrubsteppe

Goal: Provide sufficient quantity and quality shrub-steppe habitat to support the diversity of wildlife as represented by sustainable focal species populations.

Habitat Objective 1: Determine the necessary amount, quality, and juxtaposition of shrub steppe by the year 2008.

Habitat Objective 2: Based on findings of Objective 1, identify and provide biological and social conservation measures to sustain focal species populations and habitats by 2010.

Habitat Objective 3: Maintain and/or enhance habitat function (i.e., focal habitat attributes) by improving agricultural practices, fire management, weed control, livestock grazing practices, and road management on existing shrub steppe.

Biological Objective 1: Determine population status of Brewer's sparrow by 2008.

Biological Objective 2: Within the framework of the Brewer's sparrow population status determination, inventory other shrub-steppe obligate populations to test assumption of the umbrella species concept for conservation of other shrub-steppe obligates.

Biological Objective 3: Maintain and enhance mule deer populations consistent with state/tribal herd management objectives.

2.7.3 Riparian Wetlands

Goal: Provide sufficient quantity and quality riparian wetlands to support the diversity of wildlife as represented by sustainable focal species populations.

Habitat Objective 1: Determine the necessary amount, quality, and connectivity of riparian wetlands by the year 2008.

Habitat Objective 2: Based on findings of Habitat Objective 1, provide biological and social conservation measures to sustain focal species populations and habitats by 2010.

Habitat Objective 3: Enhance beaver habitat where appropriate to increase the quantity and quality of riparian wetlands for focal species by 2009.

Habitat Objective 4: Enhance beaver populations to benefit habitat for threatened/endangered fish species

Habitat Objective 5: Maintain and/or enhance habitat function (i.e., focal habitat attributes) by improving silviculture and agricultural practices, fire management, weed control, livestock grazing practices, and road construction and maintenance on and adjacent to existing riparian wetlands.

Biological Objective 1: Determine population status of red-eyed vireo yellow-breasted chat by 2008.

Biological Objective 2: Within the framework of the focal species population status determinations, inventory other riparian wetlands obligate populations to test assumption of the umbrella species concept for conservation of other riparian wetlands obligates.

2.8 Summary of Restoration and Conservation Measures: Aquatic

2.8.1 Lower Entiat Assessment Unit

Water Quality

- Improve elevated water temperatures and excessive fine sediments
- Reduce the levels of toxic materials and contaminants entering into the stream system

Water Quantity

- Increase efficiency of water withdrawal
- Decrease severity of high flow events by increasing in-channel structural diversity and restoring geo-fluvial processes

Riparian/Floodplain Conditions

- Reestablish riparian vegetation corridors and associated stream canopies
- Increase the number of large trees and complex riparian communities
- Minimize affects of development on channel migration zones within the riparian and floodplain, and increase stream sinuosity through active restoration when feasible
- Increase, or reconnect floodplain (off-channel) habitats, where feasible
- Maintain and enhance wetland complexes and enhance ground water recharge
- Where feasible, relocate roads from the valley bottoms

In-Channel Conditions

- Increase in-stream structural diversity and complexity to provide refuge to juveniles
- Increase/restore habitat diversity by increasing off-channel habitat, backwaters with cover and low energy refugia
- Evaluate the use of irrigation ditches as a means to increase rearing
- Increase large woody debris and provide adequate sources for future recruitment
- Increase quality and quantities of pool habitat

Barriers to Fish Passage

- Maintain passage in the mainstem and improve fish passage in the tributary streams

Ecological Conditions

- Reduce harassment to spawning and pre-spawning adult salmonids
- Evaluate Pacific Lamprey populations and habitat suitability

Minimize fish and bird predation on salmonids

- Improve nutrient base using salmon carcasses or suitable analog
- Minimize hatchery contribution of pathogens
- Minimize negative impacts of hatchery operations
- Enhance the nutrient base using salmon carcasses or analog materials

2.8.2 Middle Entiat Assessment Unit

Water Quality

- Decrease fine sediment and maintain trend

Water Quantity

- Moderate severity of high flow events by enhancing floodplain conditions and in-channel complexity

Riparian/Floodplain Conditions

- Improve riparian vegetation corridors and associated stream canopies
- Increase/maintain the number of large trees and complex riparian communities that will eventually increase the natural recruitment of large wood
- Reduce impacts from development and livestock management within the riparian area
- Reduce road density in riparian areas
- Minimize affects of development on channel migration zones within the riparian and floodplain, and increase stream sinuosity in tributary streams
- Increase, or reconnect floodplain (off-channel) habitats, where feasible
- Maintain and enhance wetland complexes, enhance ground water recharge
- Protect/enhance geo-fluvial processes and floodplain function

In-Channel Conditions

- Maintain and enhance in-stream structural diversity and complexity to provide refuge to juveniles
- Protect and increase in-stream structures (complex log structures)
- Increase stream bank stability
- Increase large woody debris and restore large wood complexes and provide adequate sources for recruitment
- Increase pool quality and quantity

Barriers to Fish Passage

- Allow unimpeded access of fish passage throughout the tributaries

Ecological Conditions

- Reduce or eliminate harassment and poaching to spawning and pre-spawning adult salmonids
- Evaluate Pacific Lamprey populations and habitat suitability
- Eliminate or reduce impacts of eastern brook trout and hatchery rainbow trout
- Maintain bull trout fishing closure and continue tracking bull trout and cutthroat trout populations
- Evaluate feasibility of coho reintroduction and begin implementation as appropriate
- Improve nutrient base using salmon carcasses or suitable analog

2.8.3 Upper Entiat and Mad River Assessment Units

Water Quality

- Maintain water temperature and decreasing trend in sediment loads

Water Quantity

- Maintain the natural hydrology of these areas and continue to improve conditions in some tributary streams

Riparian/Floodplain Conditions

- Maintain existing conditions throughout much of these areas; improve localized conditions in some tributaries

In-Channel Conditions

- Maintain good conditions and improve structural diversity in some areas in the lower Mad River and Tillicum Creek

Barriers to Fish Passage

- Maintain unimpeded access to fish passage throughout these areas and improve access in lower Tillicum Creek

Ecological Conditions

- Reduce or eliminate harassment and poaching to spawning and pre-spawning adult salmonids
- Evaluate Pacific Lamprey populations and habitat suitability
- Eliminate or reduce impacts of eastern brook trout and hatchery rainbow trout
- Maintain bull trout fishing closure and continue tracking bull trout and cutthroat trout populations

- Improve nutrient base using salmon carcasses or suitable analog

2.9 Summary of Monitoring and Infrastructure Needs: Terrestrial

Recommended monitoring and evaluation strategies summarized below for each focal habitat type are derived from national standards. Deer and elk sampling methodology follow standard protocols established by the Washington Department of Fish and Wildlife. Protocols for specific vegetation monitoring/sampling methodologies are drawn from USDA Habitat Evaluation Procedure standards. A common thread in the monitoring strategies contained in this Subbasin Plan is the establishment of permanent census stations to monitor bird populations and habitat changes.

Wildlife managers will include statically rigorous sampling methods to establish links between habitat enhancement prescriptions, changes in habitat conditions, and target wildlife population responses.

Specific methodology for selection of Monitoring and Evaluation (M&E) sites within all focal habitat types follows a probabilistic (statistical) sampling procedure, allowing for statistical inferences to be made within the area of interest. Protocols identified in this document describe how M&E sites will be selected. The following summarizes the basic concepts of the Wildlife Monitoring Strategy.

2.9.1 Ponderosa Pine

Focal Species

Flammulated owl, white-headed woodpecker, and pygmy nuthatch.

Overall Habitat and Species Monitoring Strategy: Establish monitoring program for protected and managed Ponderosa pine sites to monitor focal species population and habitat changes and evaluate success of efforts.

Focal Habitat Monitoring

Factors affecting habitat:

- Direct loss old growth forest and associated large diameter trees and snags
- Fragmentation of remaining Ponderosa pine habitat
- Agricultural and sub-urban development and disturbance
- Hostile landscapes which may have high densities of nest parasites, exotic nest competitors, and domestic predators
- Fire suppression/wildfire
- Overgrazing
- Noxious weeds
- Silvicultural practices
- Insecticide use

2.9.2 Shrubsteppe

Focal Species

Sharp-tailed Grouse, Brewer's sparrow, and mule deer.

Overall Habitat and Species Monitoring Strategy: Establish monitoring program for protected and managed shrub-steppe sites to monitor focal species population and habitat changes and evaluate success of efforts.

Focal Habitat Monitoring

Factors affecting habitat:

- Direct loss shrub steppe due to conversion to agriculture, residential, urban and recreation developments
- Fragmentation of remaining shrub-steppe habitat, with resultant increase in nest parasites
- Fire Management, either suppression or over-use, and wildfires
- Invasion of exotic vegetation
- Habitat degradation due to overgrazing, and invasion of exotic plant species
- Loss and reduction of cryptogamic crusts, which help maintain the ecological integrity of shrub-steppe/grassland communities

2.9.3 Riparian Wetlands

Focal Species

Red-eyed vireo, yellow-breasted chat, and American beaver

Overall Habitat and Species Monitoring Strategy: Establish monitoring program for protected and managed Riparian Wetland sites to monitor focal species population and habitat changes and evaluate success of efforts

Overall Habitat and Species Monitoring Strategy: Establish permanent census stations to monitor bird population and habitat changes

Focal Habitat Monitoring

Factors affecting habitat:

- Direct loss of riparian deciduous and shrub understory
- Fragmentation of wetland habitat
- Flooding and dewatering of areas by beaver
- Agricultural and sub-urban development and disturbance
- Reduction in water quality

- Organochlorines such as dieldrin or DDE may cause thinning in egg shells which results in reproductive failure

2.10 Summary of Monitoring and Infrastructure Needs: Aquatic

The monitoring plan draws from the existing regional strategies (Independent Scientific Advisory Board, Action Agencies/NOAA Fisheries, and Washington Salmon Recovery Funding Board) and outlines an approach specific to the Entiat Basin. The plan addresses the following basic questions:

What are the current habitat conditions and abundance, distribution, life-stage survival, and age-composition of ESA-listed fish in the Entiat Basin (status monitoring)?

How do these factors change over time (trend monitoring)?

What effects do tributary habitat actions have on fish populations and habitat conditions (effectiveness monitoring)?

The monitoring plan is designed to address these questions and at the same time eliminate duplication of work, reduce costs, and increase monitoring efficiency. The implementation of valid statistical designs, probabilistic sampling designs, standardized data collection protocols, consistent data reporting methods, and selection of sensitive indicators will increase monitoring efficiency. For this plan to be successful, all organizations involved must be willing to cooperate and freely share information. Cooperation includes sharing monitoring responsibilities, adjusting or changing sampling methods to comport with standardized protocols, and adhering to statistical design criteria. In those cases where the standardized method for measuring an indicator is different from what was used in the past, it may be necessary to measure the indicator with both methods for a few years so that a relationship can be developed between the two methods. Measurements generated with a former method could then be adjusted to correct for any bias.

The monitoring report is divided into seven major parts. The first part (Section 2) identifies valid statistical designs for status/trend and effectiveness monitoring. Section 3 discusses issues associated with sampling design, emphasizing how one selects a sample and how to minimize measurement error. Section 4 examines how sampling should occur at different spatial scales. Section 5 describes the importance of classification and identifies a suite of classification variables. Section 6 identifies and describes biological and physical/environmental indicators, while Section 7 identifies methods for measuring each indicator variable. These six sections provide the foundation for implementing an efficient monitoring plan in the Entiat Basin. The last section deals with how the program will be implemented. Section 8 provides a checklist of questions that need to be addressed in order to implement a valid plan.

At this time entities that collect information relevant to fish and wildlife interests in the Entiat subbasin do not have a centralized location to store or retrieve critical or timely information. Key questions yet to be addressed at the subbasin and Regional level concerns data management, data interpretation and data presentation. One of the significant challenges yet to be resolved is in describing the organizational and cooperative manner in which agencies and entities can integrate the regular collection and interpretation of natural resource information and provide this information to the public in a manner that allows full involvement in future decision making processes.

3 Subbasin Overview

3.1 Entiat Subbasin in Regional Context

3.1.1 Introduction and Objectives

The Northwest Power and Conservation Council (NPCC) is responsible for implementing the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (P.L. 96-501) and the Fish and Wildlife Program mandated by the act. For planning purposes, the NPCC divided the more than 50 subbasins comprising the Columbia River Basin south of the Canadian border into 11 ecoregions.

Each of the 11 ecological provinces will develop its own vision, biological objectives, and strategies consistent with those adopted at the subbasin level. NPCC's intent is to amend these Subbasin plans into the 2000 Fish and Wildlife Program during later rulemaking. The biological objectives at the province scale will then guide development of the program at the subbasin scale.

3.1.2 Columbia Cascade Province

The Columbia Cascade Ecological Province extends over an area of 14,333 sq. mi. It is defined as the Columbia River from Wanapum Dam to the limit of anadromous fish passage at Chief Joseph Dam and is situated in north central Washington. Tributary subbasins are, for the most part, high gradient streams that begin in the North Cascade Mountains and drain directly to the Columbia River. The province also includes a few smaller streams that drain smaller watershed adjacent to the Columbia as well as a number of gulches that arise from the channeled scablands to the east. The province is divided into 6 subbasins: the Entiat, Entiat, Lake Chelan, Methow, Okanogan, and Upper Middle Mainstem Columbia River.

The Entiat subbasin lies entirely within Chelan County. The subbasin comprises 3.2% of the Columbia Cascade Province and consists of approximately 298,000 acres (466 mi^2), as referenced in Table 1.

Table 1. Entiat subbasin in provincial context

Subbasin	Size		Percent of Province	Percent of State
	Acres	Mi²		
Entiat	**298,363**	**466**	**4.9**	**.7**
Lake Chelan	599,925	937	**10**	1.4
Wenatchee	851,894	1,333	**14,1**	2.0
Methow	1,167,795	1,825	**19.4**	2.8
Okanogan	1,490,079	2,328	**24.8**	3.5
Upper Middle Mainstem Columbia River	1,607,740	2,512	**26.7**	3.8
Total (Columbia Cascade Province)	**6,015,796**	**9401**	**100**	**14.2**

Ashley and Stovall 2004

Note: Values may be somewhat inconsistent with other tables in this document due to differing sources of information. Values may be revised as significant errors are discovered and time is available.

Approximately 83% of the subbasin is in federal (primarily USFS) and state ownership. The remaining 17% of the lands in the subbasin is in private ownership as referenced inTable 2, below.

Table 2. Land ownership of the Columbia Cascade Province

Subbasin	Federal Lands (acres)	Tribal Lands (acres)	State Lands (acres)	Private Lands (acres)	Total (Subbasin) (acres)
Entiat	**247,064**	**0**	**13,629**	**37,670**	298,363
Lake Chelan	517,883	0	3,549	78,493	599,925
Wenatchee	682,295	0	11,836	159,182	853,313
Methow	985,234	0	55,836	126,724	1,167,794
Okanogan	400,496	311,826	261,598	516,159	1,490,079
Upper Middle Mainstem Columbia River	124,492	29,507	284,996	1,168,744	1,607,739
Total (Province)	**2,957,464**	**341,333**	**631,444**	**2,086,972**	**6,017,213**

Ashley and Stovall 2004

Note: Values may be somewhat inconsistent with other tables in this document due to differing sources of information. Values may be revised as significant errors are discovered and time is available.

Native American Tribes

Native people traditionally lived, hunted, gathered and fished within the Columbia Cascade Ecological Province. The province includes land ceded by the Confederated Tribes and Bands of the Yakama Nation (Yakama Nation) under the Treaty of 1855 to the United States. Members of the Yakama Nation and the Confederated Tribes of the Colville Reservation continue to exercise their hunting, gathering, and fishing rights within the province.

3.1.3 Terrestrial/Wildlife Context

For the most part, the Columbia Cascade Ecological Province shares many of the same problems and opportunities for fish and wildlife habitat conditions as other Provinces within the interior Columbia Basin. The upper watersheds are primarily forested and have undergone substantial management activities. Lower reaches of the principal streams within each of the subbasin are almost completely privately owned and primarily managed through agricultural practices. In all cases, habitat conditions range from pristine to severely altered.

3.1.4 Aquatic/Fish Context

Construction of Grand Coulee Dam in 1934 blocked over 1,000 miles of habitat in the Upper Columbia River Basin upstream of the Columbia Cascade Province. Another 52 miles of habitat was blocked, in 1961, by the completion of the Chief Joseph Dam. In addition, there are six hydroelectric projects downstream of this Province: Wanapum Dam and Priest Rapids Dam, and four federally owned projects, McNary Dam, John Day Dam, The Dalles Dam and Bonneville Dam.

To mitigate for the loss of anadromous salmonid production by the federally built projects, the federal government built and continues to operate the Leavenworth National Fish Hatchery in the Wenatchee subbasin and later the Entiat and Winthrop National Fish Hatcheries in the Entiat and Methow subbasins, respectively. No federal mitigation facility was constructed in the Okanogan subbasin.

With the construction of each of the privately owned Mid-Columbia hydroelectric projects, additional production/hatchery facilities were developed in the Columbia Cascade Province. The recent Habitat Conservation Plan (initiated by Chelan and Douglas Public Utility Districts (PUDs) for ESA Section 10 consultation) identified the mitigation obligation of the PUDs and provides the groundwork for future changes in facility production goals and operations. Details of these changes in hatchery production will be resolved over the next few years.

In spite of past mitigation efforts, declining salmonid populations in the Columbia Cascade Province have resulted in listings of spring chinook (Oncorhyncus tshawytscha) (endangered March 1999), summer steelhead (O. mykiss) (endangered August 1997) and bull trout (Salvelius confluentus , June 1998) under the ESA. Upper Columbia late-run chinook and Lake Wenatchee sockeye (O. nerka) were also petitioned (March 1998) but were determined not warranted for listing. Recent years have shown improved salmonid runs to the Province, consistent with findings throughout the Columbia Basin.

3.1.5 Subbasin Planning and the Regulatory Context

Federal

The USFS manages approximately 83% of the Entiat subbasin. Other federal land mangers include the BLM and the USFWS, which is responsible for the operation and management of the Entiat National Fish Hatchery. Actions on USFS, BLM and USFWS lands within the Entiat subbasin result from the execution of various federal laws and regulations. Some of the major federal laws governing agency practices that were considered during the development of this plan are described in this section.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) of 1969 mandates that all federal agencies "utilize a systematic, interdisciplinary approach that will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision making, which may have an impact on man's environment." NEPA integrates with a wide variety of existing environmental legislation, including the: Clean Air Act (CAA), Clean Water Act (CWA), Coastal Zone Management Act (CZMA), National Historic Preservation Act (NHPA), Marine Protection, Research and Sanctuaries Act (MPRSA), Pollution Prevention Act (PPA), and the Endangered Species Act (ESA). NEPA further requires a detailed statement on the environmental impact of major federal actions that significantly affect the environment be included in every recommendation or report on proposals for legislation.

Endangered Species Act

The Endangered Species Act (ESA) of 1973 applies to the management of fish, wildlife and plant species that are in danger of or threatened with extinction. The purpose of the ESA is to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, and to provide a program for the conservation of such threatened and endangered species. All federal departments and agencies must seek to conserve threatened and endangered species and utilize their authorities to further the purposes of the ESA. Federal agencies are also required to cooperate with state and local agencies to resolve water resource issues in concert with conservation of endangered species.

In addition to mandating specific federal management actions, the ESA also applies to the actions of any person subject to the jurisdiction of the United States. It prohibits the harm or "take" of species listed as threatened or endangered under the ESA. Significant consideration is given to the ESA when any type of activity within the Entiat subbasin is proposed or undertaken, as threatened and endangered species exist within the management area on lands under both public and private management. Proposed habitat recommendations in this plan have been designed to help protect and restore threatened bull trout and endangered steelhead and spring chinook habitat on private lands within the subbasin.

Clean Water Act

The Federal Water Pollution Control Act of 1972, as amended in 1977, is commonly known as the Clean Water Act (CWA). The CWA established a basic structure to regulate discharge of pollutants into U.S. waters, and gave the U.S. Environmental Protection Agency (EPA) the authority to implement pollution control programs. The EPA set federal water quality standards, and delegated authority to the WDOE to monitor whether state surface waters are meeting federal water quality standards. The state is also required to maintain a list of impaired streams. The water quality recommendations in this plan have been designed to help address these concerns within the Entiat subbasin.

Federal Land Policy and Management Act

The Federal Land Policy and Management Act (FLPMA) requires the BLM to develop land use plans. In order to meet this requirement the BLM developed the Spokane Resource Management Plan, which includes lands within the Entiat subbasin. BLM administered lands in the subbasin are designated as Scattered Tracts, and allow most resource activities including recreation, timber harvest, and grazing. These lands have high value as wildlife winter range.

National Forest Management Act and Northwest Forest Plan

The National Forest Management Act (NFMA) is significant law affecting the management and decisions of Forest Service land managers. The NFMA directs the USFS to develop a Resource Management Plan (RMP) for each national forest. The 1990 Entiat Forest Plan contains management direction for the forest in the form of forest-wide standards and guidelines and management prescriptions for specific management areas (USFS Entiat NF 1990). The various management areas emphasize certain key values and indicate what practices will and/or will not occur within each management area.

The Northwest Forest Plan amended the Entiat Forest Plan in April 1994. This amendment modified the Entiat Forest Plan management designations and created Late Successional and Riparian Reserves. The Northwest Forest Plan also provides numerous standards and guidelines directing management practices on federal lands. Table 3 summarizes the resulting NFS land allocations by acreage within the Entiat subbasin and describes permitted management actions.

Table 3. USFS land allocations, acreages, and management emphasis

LAND ALLOCATION	ACRES+	MANAGEMENT EMPHASIS
Congressionally Withdrawn Areas	25,554.37	Part of the Glacier Peak Wilderness Area. Managed for primitive recreation and research in a primitive setting. No timber harvest.
Late-Successional Reserves	60,139.33	Managed to protect and enhance habitat for late-successional and old-growth related species. No scheduled timber harvest, but allows some tree thinning to enhance desired late successional/old-growth habitat.
Administratively Withdrawn	34,834.61	Entiat Forest Plan: Unroaded Dispersed Recreation. No timber harvest.
Riparian Reserves*		Emphasizes protection along all streams, wetlands, ponds and lakes. No scheduled timber harvest but some silvicultural treatments are permitted when they benefit riparian resources.
Matrix*	130,822.96	Lands outside of reserves and managed under prescriptions described in The Entiat Forest Plan land allocations. Approximately 65% or 62,958 acres are available for regularly scheduled timber harvest.
Forest Service Pending	3531.31	Lands acquired through exchange or purchase that do not have a Forest Plan allocation assigned to them yet.

CCCD 2004

In addition to creating reserves and prescribing standards and guidelines, the Northwest Forest Plan identified “key watersheds" in Washington, Oregon and Northern California as part of the Aquatic Conservation Strategy. Key watersheds provide habitat critical for the maintenance and recovery of anadromous salmonids and resident fish species.

The Northwest Forest Plan requires that watershed assessments be completed before federal land managers proceed with most activities within key watersheds. Each of these plans has been completed in the Entiat Subbasin and is incorporated into this document.

A key product of the watershed assessment process was the description of existing resource conditions, identification of desired ecological conditions, and the development of management strategies that would move elements in the watershed toward the desired future condition.

State

Many Washington state laws that regulate actions on private lands within the Entiat subbasin and that direct state and local agency decision-making about projects were also considered while developing this plan. Some of these pertinent state laws include, but are not limited to:

Salmon Recovery Act of 1998 (Chapter 75.46 RCW) and Watershed Planning (Chapter 90.82 RCW)

Additional detail about the Salmon Recovery Act (SRA) is provided below because of the close link between SRA and the State Watershed Planning Act. For more information about these and other state laws, see the following link: http://www.leg.wa.gov/rcw/index.cfm

The Salmon Recovery Act authorizes a Lead Entity to coordinate the development of locally-directed Habitat Restoration Project Lists and salmon recovery plans. The Lead Entity for salmon recovery activities occurring in Chelan County is the county. If a planning unit opts to include the habitat component in its plan, and restoration activities are already being developed under the Salmon Recovery Act, the planning unit is required to rely upon those activities as "the primary non-regulatory habitat component" of their plan.

The habitat restoration actions put forth in this plan were developed using the Critical Pathways Methodology identified in the Salmon Recovery Act, and are the result of a locally-directed, collaborative effort among federal, tribal, state, local, and other stakeholder interests.

Various State legislative actions have provided guidance to natural resource management. Several of the more important regulatory Acts are listed below:

- Shoreline Management Act of 1971 (Chapter 90.58 RCW)
- Water Resources Act o f 1971 (Chapter 90.54 RCW)
- Growth Management Act of 1990 (Chapter 36.70A RCW)
- Forestry Practices Act of 1974 (Chapter 76.09 RCW)
- State Environmental Policy Act of 1971 (Chapter 42.21C RCW)

Regional/Local

Regional Salmon Recovery Planning

It is anticipated that information contained in this document pertinent to habitat restoration and salmon recovery in the Entiat subbasin will contribute to the regional recovery strategy being developed for the Columbia Cascade Province.

Tribal Recovery Planning; Wy-Kan-Ush-Mi Wa-Kish-Wit (Spirit of the Salmon)

Wy-Kan-Ush-Mi Wa-Kish-Wit (Spirit of the Salmon) is the Columbia River anadromous fish restoration plan of the Nez Perce, Umatilla, Warm Springs and Yakama Tribes developed with the Columbia River Inter-Tribal Fish Commission (CRITFC). One of the plan's long-term objectives is to restore salmon populations to a level that will support tribal ceremonial, subsistence, and commercial harvests. For more information on Tribal Recovery, refer to the following link: http://www.critfc.org/text/water_action.html

Chelan County Comprehensive Land Use Planning

Planning units are required to consider city and county planning activities during the development of their watershed plan. The Entiat Planning Unit has given particular attention to local planning being done under the Growth Management Act (GMA). GMA is quite significant in that it mandates cities and counties to plan for land use and development; designate and protect critical areas including wetlands, aquifer recharge areas, frequently flooded areas, and fish and wildlife habitat conservation areas. GMA also guides the development of comprehensive plans using other goals such as enhancing water quality and water availability, promoting new businesses, and involving citizen participation in the planning process. Actions recommended in this plan were designed in consideration of the goals used to guide planning under GMA, and to provide local input to Chelan County during the update of its Comprehensive Plan, which is scheduled for completion by December 1, 2006. To access Chelan County Comprehensive Plan documents, refer to: http://www.co.chelan.wa.us/bl/bl4.htm

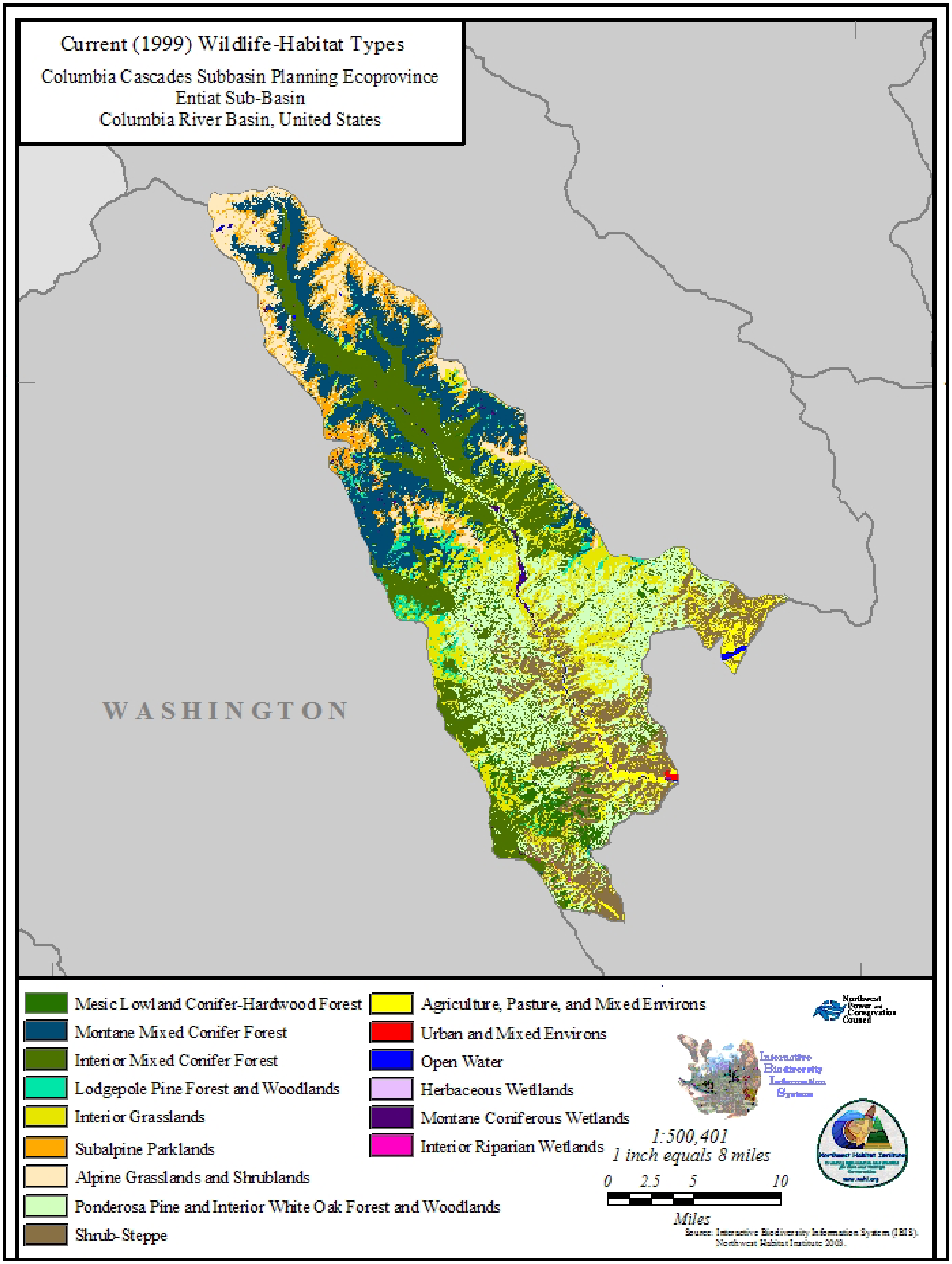


Figure 2. Major vegetation and wildlife habitat types in the Entiat subbasin

3.2 Subbasin Description

3.2.1 Location

The Entiat subbasin is located along the eastern slopes of the Cascade Mountains in north-central Washington State, Chelan County. It comprises the Entiat and Mad River watersheds, collectively known as the Entiat subbasin, as well as some minor Columbia River tributary drainages. The subbasin is approximately 305,641 acres and bounded on the northeast by the Chelan Mountains and the Lake Chelan drainage; to the southwest are the Entiat Mountains and the Entiat River subbasin.

3.2.2 Topography and Climate

Most of the large-scale topographic features are the result of alpine glaciation, which significantly affected the upper half of the Entiat subbasin. During the neo-glaciation period a valley glacier nearly 25 miles long extended from its source at the headwall of the Entiat watershed to just below Potato Creek, which is marked by a terminal moraine indicating the furthest downstream influence of the glacier on channel geomorphology and bed material. Above the terminal moraine the Entiat valley has a characteristic U-shaped appearance and is covered with glacial till. Glaciation resulted in hanging valleys and a moderately broad floodplain in the mid Entiat River that contains water-stratified silt, sand, gravel and cobbles (CCCD 2004).

Climate in the Entiat subbasin is strongly influenced by its association with the Cascade Mountains. Climate is discussed below in averages for winter and summer; however, fluctuations outside of average are very common, and extremes may best describe the local climate. Examples of such extremes include temperatures in the 90s and 100s, which may last for several weeks at a time during the summer, and single digit and sub-zero temperatures (occasionally double digit) for short periods during many winters.

Mean annual precipitation can range up to 90 inches in the headwater areas near the Cascade crest to less than 10 inches along the Columbia River. Approximately 50% of the mean annual precipitation falls from October through January, and 75% falls from October through March. Most winter precipitation falls as snow; however, rain is not unusual at some mid- and lower elevations. Cumulative snow depths range from less than 24 inches in lower elevations to nearly 400 inches. Precipitation in July and August, the two driest months, is 5-10% of the annual mean. High intensity, short duration thunderstorms frequently develop over the mountains in the summer, resulting in heavy downpours of short duration. Occasionally these heavy rains produce flash floods. Records from 1949 to1992 from climatological stations in the surrounding area do not show any definitive increasing or decreasing trend in annual precipitation (Kirk et al. 1995).

Average daily summer temperatures in the mid-elevations range between 60 and 70°F, decreasing to the 50s at higher elevations. High temperatures in the 90s frequently occur in the lower valley during July and August. In winter, storm systems moving east from the Pacific, as well as outbreaks of cold air from the north produce frequent weather changes. During an average winter, temperatures range from the teens to the 40s depending on elevation. The frost-free season is generally mid-May through early October; however, frost in the lower valley has occurred as late as the first week in June. The first frost of the fall is likely to occur about October 1. The average growing season in the agricultural area of the subbasin averages 150 days; the upper valley experiences a shorter growing season due to increased elevation and later departure/earlier onset of frost (CCCD 2004).

3.2.3 Land Ownership and Land Use

Ownership patterns in the Entiat subbasin result from public domain, railroad land grants, homestead and timber entries, and subsequent land sales and exchanges. The majority of privately owned land is located within one mile of the mainstem Entiat River in a band that extends 26 miles upriver. The settlement pattern along the valley bottom is a result of accessibility and the land's agricultural suitability. There are some privately held sections intermingled with national forest lands outside of the valley bottom area in the eastern portion of the watershed. This checkerboard ownership pattern is a result of railroad land grants.

Ownership within the subbasin is predominantly public, with slightly less than nine percent of the land in private ownership. The US Forest Service (USFS) manages approximately 83% of lands within the subbasin. Other notable federal land owners include the Bureau of Land Management (BLM) and the US Fish and Wildlife Service (USFWS). Almost all state lands are managed by either the Washington Department of Fish and Wildlife (WDFW) or the Washington Department of Natural Resources (WDNR). Table 4 provides an overview and depiction of primary land ownership in the Entiat subbasin (CCCD 2004).

Table 4. Land ownership in the Entiat subbasin by acreage and percentage

Owner	Approximate Acreage*	Percentage of Subbasin
Federal	258,477	84.6%
BLM	4424	
USFWS	798	
USFS	253,255	
State	17,467	5.7%
WDFW	7525	
WDNR	9930	
Other	12	
County/City/Local	361	0.1%
Chelan County	2	
City of Entiat	68	
City of Seattle	261	
Districts (Fire, Cemetery, Irrigation, School)	30	
Private	26,720	8.8%
NCW Museum	36	
Chelan-Douglas Land Trust	415	
Longview Fiber Company	9878	
Chelan County PUD	543	
Boat Club	32	
Other	15,816	
Columbia River	2436	0.8%
TOTAL	**305,641**	**100%**

* GIS analysis of USFS ownership, Chelan County parcel, and WDOE WRIA information

Historic Land Use

This overview is based on information taken from the Entiat Draft Watershed Plan (2004).

The Entiat valley has been shaped in large part by a long history of natural disturbance events such as wildfire, flooding, earthquakes, landslides, glaciation, and volcanic eruptions. Wildfire and flooding are very common events in the subbasin, as evidenced by the past 50 years; wildfires in 1970, 1976, 1988, and in 1994 affected over 60% of the subbasin. The most significant flood recorded occurred in 1948. Other significant floods occurred in 1972, twice in 1977, and in 1989 following wildfire events.

Native Americans used the Entiat valley for hunting and gathering prior to its use by trappers and settlers of European origin. Bitterroot was gathered on the lower valley hillsides, and is still relatively common in some locations today. Native Americans also harvested game from the forests and grasslands, and fish and other water dependent species from the river and its tributaries. The Yakama Nation, under the 1855 Treaty with the Yakama, maintains rights for hunting and gathering in the subbasin.

Trapping in the 1880s was the first non-Native American activity to occur in the Entiat subbasin. Trapping continued through the 1980s and into the 1990s as a source of revenue for some current residents' ancestors.

Sheep grazing also began about 1880, and was one of the most extensive earlier uses of the valley. Various sources indicate that more than 13,000 (13,000 to 16,000) sheep grazed the valley in the late 1800s and early 1900s. The Plummer report indicated that in 1902 there were upwards of 60,000 sheep along the head of Mad River (USDI Geologic Survey 1902). In the 1940s sheep grazing on federal lands in the Entiat was cut back from two to three bands (1,000 sheep/band) to one band annually, the number allowed to graze for 1-2 months annually or semi-annually today.

Cattle and horses also used the valley, although not as heavily or extensively as sheep. In the early 1900s, wild horses were rounded up and brought to the railroad stockyard at Entiat. Hogs and dairy cows were grazed in a few locations. The number of cattle now grazing on federal lands is less than 200 head, with approximately another 100 head using private lands for part of the year.

Between 1885 and 1910 gold and other minerals were prospected for and mined in the valley. Most of this activity was concentrated around Crum Canyon. Pumice was taken out of open pit mines between Stormy Creek and Cottonwood in the late 1940s, and commercial pumice was mined in Stormy Creek up until 1956.

Logging within the valley has had a rich and varied history. In 1892 the first log mill was established near the mouth of the Entiat River. Logging began to increase early in the twentieth century in response to home construction and the apple box industry. Other mills were built near the mouth of the river and in some of the lower river tributaries, including Mills Canyon, Crum Canyon, and Muddy Creek (Mud Creek). Small portable mills were also located within the valley.

Most of the road network that exists within the subbasin today was constructed by 1980 for access to timber sales. Timber harvest reached its peak in the valley just after the 1970 Entiat

Fires; between 1972 and 1977 almost 50 million board feet of fire salvage timber was sold from national forest lands.

The Entiat River had a varied history of impoundment between the late 1880s and the first half of the 1900s. A holding dam associated with the Harris-Cannon sawmill was constructed near the mouth of the river in 1898. In 1904 Gray built an electric power plant at the site of the dam; the plant experienced winter closure due to low water levels from 1905-1906. A log-holding dam was also built in 1904, in association with a sawmill constructed in Mills Canyon. In 1909, C.A. Harris constructed a dam and power plant about 1.5 miles up the river, near the present day Keystone Bridge. In some years only a little water remained in the channel below the Harris dam. In 1932 the Harris mill moved from Mud Creek to the mouth of the Mad River at Ardenvoir (RM 10.5) and some remnants of the 13.5 foot high log storage dam constructed to serve the mill are still evident just upstream of Cooper's store. U.S. Bureau of Fisheries surveys in 1934, 1935 and 1936 noted that three dams still remained on the Entiat River (Bryant and Parkhurst 1950). Of the three, the last to remain was the Ardenvoir Mill dam, which was washed out in the 1948 flood and never rebuilt.

Fruit production has always been very important to the local economy. The first orchard irrigation ditch, built in 1887, was the Hanan-Detwiler ditch. In 1888 a small peach orchard was planted near the mouth of the river; a ditch used prior to that time for placer mining, was the irrigation source. By 1889-90 almost every homesteader had some fruit trees for subsistence, and the growing conditions in the lower valley were favorable. The Entiat Improvement Co. Ranch constructed a ditch in 1894 that ran from four miles upriver downstream to the mouth and Ribbon Cliff. The Knapp-Wham ditch was filed for in 1903 and was furnishing water to three and one-half miles of land on the south side of the Entiat River between Roaring Creek and Keystone Canyon by 1905. Several other ditches exist today for both orchard and/or hay and pasture irrigation.

Valley residents and others have enjoyed hunting and fishing in the Entiat valley for many years. Hunting mule deer and fishing for local trout were important recreational and subsistence activities for local residents. They feel that deer numbers may be higher now than in the past, and remember a significant winterkill in 1943. Senior lifelong residents recall that when they were younger it was relatively easy to catch a 20 fish limit, and that there were at least two bull trout in the limit. They feel that this fishery has declined significantly since in the 1940's. Residents do not recall significant salmon runs but have heard stories from earlier residents of significant steelhead spawning activity in the Mad River. Early Bureau of Fisheries surveys of the Entiat River from the 1930s showed that it was virtually devoid of salmon (Bryant and Parkhurst 1950).

Current Land Use

Current land uses within the Entiat WRIA include agriculture, primarily pear and apple orchards; livestock production and grazing; timber harvest; residential housing; and recreation.

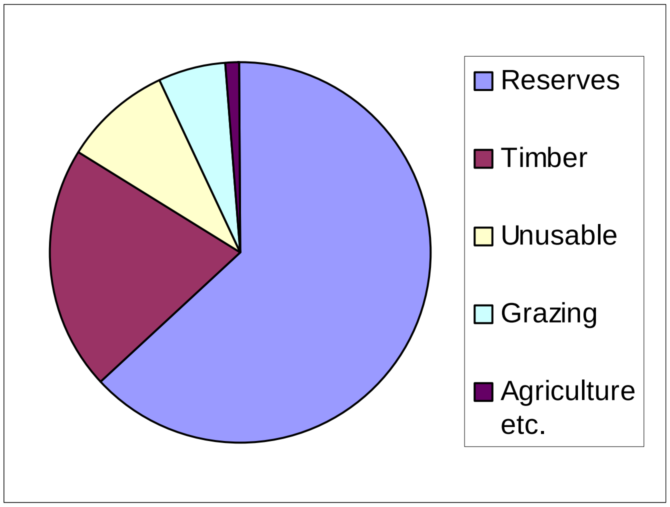


Figure 3. Aproximate land use percentages in the Entiat subbasin

Figure 3 approximates the percentage of various land use areas within the Entiat subbasin. Wilderness, old growth reserves, wildlife and riparian reserves comprise 63% of the USFS reserves land designation, which includes some areas in the lower valley that currently do not fall within the other land use categories. Reserve areas are primarily used by wildlife, but are not specifically designated for wildlife use. The unusable category is land intermingled with designated timber and/or grazing lands that is unsuitable for these uses due to topography or productivity, or is inaccessible for other reasons such as rock or cliff formations. Irrigated agriculture land area comprises 0.4% of the watershed, and with developed recreation areas (including trails) and residential areas, makes up approximately 1% of the total land area. For a more comprehensive discussion of the existing land uses, refer to the Entiat WRIA 46 Management Plan (2004).

3.2.4 Hydrology

Climate and topography create a wide range in annual precipitation. The capture, storage and release of precipitation control many of the Entiat subbasin's physical and biological processes. A large portion of the annual precipitation falls as snow and accumulates to form the winter snowpack. Warm spring temperatures and rain release water accumulated in snowpack as runoff. Thus, snowmelt is the dominant source of streamflow and groundwater in the subbasin. Occasional, large frontal and convective storms in the spring, summer and fall may increase flow or cause flooding.

Annual water yield from the Entiat subbasin varies considerably from year to year. Steep topography, relatively short drainage length, pinnate drainage structure, and other factors promote a rapid mainstem flow response time to runoff and a wide range between peak flows and low flows in the lower Entiat River. Mean volume produced from 1951-1958 by the Entiat subbasin (419 sq. mile drainage area), as recorded at the mouth by the Entiat at Entiat gage, was 367,379 acre-feet. Mean annual volume recorded at the same site for the period 1970-1976 was 528,275 acre-feet, indicating a 44% increase in yield during the period following the 1970 fires (USDA 1979). Mean annual runoff recorded upstream at the Entiat near Ardenvoir gage (203 sq.

mile drainage area) for the period 1957-1999 was 283,527 acre-feet, with an annual high of 451,140 acre-feet in 1972 and a low of 178,970 acre-feet in 1973.

Mean monthly runoff data for the Entiat subbasin are indicative of a snowmelt dominated system, and the alluvial and glacially derived sediments in the valley bottoms are the primary storage for groundwater in the Entiat subbasin. A pattern of high elevation snowmelt, aquifer recharge, and the gradual release of groundwater defines stream flows in the Entiat subbasin. Snowmelt influences on peak flows in lower elevation tributaries (e.g., Mud Creek) can begin as early as February; however, the vast majority of the annual runoff typically occurs during the period between early May and mid-July when mid to upper elevation snowmelt reaches its peak. Groundwater movement into the Entiat River and its tributaries from late summer through the winter helps sustain stream flows for the remainder of the year. This exchange of water between sub-surface and surface flows is a function of the height of the water table in relation to the channel.

High flows in the Entiat subbasin commonly result from either rapid spring snowmelt; large storms (1948 and 1972), including warm rain-on-snow events; or high intensity convective storms. Post-fire flooding triggered by one of these mechanisms is a frequent disturbance process. Since 1970, flooding has followed most major fires in the subbasin. The 1972 flood was a drainage-wide event resulting from a large frontal storm combined with the late melt of a record snow pack. The Preston Creek debris torrent that occurred during this event originated from lands burned in 1970. The Crum/Ringsted/Byrd Canyon floods of 1977, the Dinkelman/Mills/Roaring flood of 1989, and the Potato Creek and Oklahoma Gulch floods of 1997 were all post-fire responses triggered by short duration, high intensity convective storms (CCCD 2004).

Water Quality

In the Entiat subbasin, all surface waters within the Entiat NF, including the Entiat River from its headwaters to the Entiat NF boundary (river mile 20.5), are classified as Class AA (extraordinary) waters. The remaining portion of the Entiat River and all tributaries feeding into it, from the Entiat NF boundary to the confluence with the Columbia River, are classified as class A (excellent) water (Andonaequi 1999).

Typically, late summer water temperatures are not a serious problem in the lower Entiat River. However, temperature and pH have exceeded state standards and the lower Entiat has been on Washington State's 303(d) list since 1992. Maximum temperatures are typically less than 15^{o} C., which is tolerable for rearing juveniles. The 1974-1986 stream temperature record for Entiat National Fish Hatchery (NFH) has a mean July-September water temperature of 13.6^{o} C. Temperature standards are periodically exceeded in the lower Mad River. At times, the pH readings at some sites reached 8.5, which exceed the WDOE standard, but the causes are not known and are assumed to be partly of natural conditions. Existing data indicate that summer water temperatures in the lower Entiat (downstream from Burns Creek) and lower Mad rivers often exceed 16^{o} C (CCPUD 1998). A study conducted by the USFS (1999) concludes that the natural geology and hydrology of the Mad River resulted in exceedences of State water quality standards without a factor of human influence. Winter anchor ice is noted in the Entiat below Ardenvoir and in the Mad River (CCPUD 1998).

Sediment levels, especially fine sediments, are affecting aquatic habitat and irrigation. These sediments are derived from both natural and human-caused (accelerated) sources (CCPUD 1998). The natural range of variability of fine sediment loading in the Entiat River subbasin is unknown; but data from sediment core sampling indicates that it may be very broad. The level of fine sediment loading is above or at the upper limit of the natural range of variability in the lower Entiat, lower Mad, Stormy-Potato, Roaring-Tamarach, lower mid-Entiat, Mud Creek, Brennegan-Preston, and Mills-Dinkleman fish productions units (Andonaegui 1999).

In some locations, failing or sub-standard septic systems and/or surface runoff from home sites may be carrying a variety of nonpoint source pollutants (e.g., pathogens, sediment, nutrients, etc.) that threaten water quality. Orchard management involves use of a number of agricultural chemicals (sprays and fertilizers) that pose a potential risk to water quality (CCPUD 1998).

Impoundments and Irrigation Projects

There are no reservoirs in the Entiat watershed although the lowest 0.5 miles of the Entiat River and floodplain is influenced by the backwatering effects of Lake Entiat, which serves as the pool for the Rocky Reach Dam Hydroelectric Facility on the Columbia River. No artificial ponds have been identified (Andonaegui 1999).

The Entiat River Subbasin Salmon and Steelhead Production Plan identified water withdrawals, both agricultural and domestic, as an issue of concern relative to their potential to exacerbate normal low flows of late summer in the Entiat River. At that time, at issue was a need to set minimum instream flows at levels that would protect not only existing fish production, but also potential fish production, where appropriate. In 1997 the WDFW Yakima Screen Shop completed their most recent ground survey inventory of irrigation structures in the Entiat valley and identified two of the six ditch diversions and eight of the 45 pump diversions that were inadequately screened. Further, two private culverts on Stormy Creek have been identified as fish passage barriers that need to be replaced (Andonaegui 1999).

3.2.5 Terrestrial/Wildlife

There are an estimated 336 wildlife species that occur in the subbasin. Of these species, 102 (30%) are closely associated with riparian and wetland habitat and 77 consume salmonids during some portion of their life cycle. Seventeen wildlife species are non-native. Five wildlife species that occur in the subbasin are listed federally and 42 species are listed in Washington and Idaho as threatened, endangered, or candidate species. A total of 98 bird species are listed as Washington or Idaho State Partners in Flight priority and focal species. A total of 57 wildlife species are managed as game species in Washington.

Ninety-two percent of the wildlife species that occur in the Province occur in the Subbasin. In addition, 65% of the amphibian species and 84 percent of the reptile species that occur in the Province occur in the subbasin.

Table 5. Species richness and associations for the Entiat subbasin

Class	Entiat	% of Total	Total (Province)
Amphibians	11	65	**17**
Birds	218	93	**234**
Mammals	91	94	**97**
Reptiles	16	84	**19**
Total	**336**	**92**	**367**

IBIS 2003

Table 6. Threatened and endangered species in the Entiat subbasin

	Common Name	Scientific Name	State Status		Federal Status
Amphibians					
	Dunn's Salamander	*Plethodon dunni*	WA	Candidate Species	
	Western Toad	*Bufo boreas*	WA	Candidate Species	
	Columbia Spotted Frog	*Rana luteiventris*	WA	Candidate Species	
	Northern Leopard Frog	*Rana pipiens*	WA	Endangered	
		Total Listed Amphibians: 4			
Birds					
	Common Loon	*Gavia immer*	WA	Sensitive	
	Western Grebe	*Aechmophorus occidentalis*	WA	Candidate Species	
	Northern Goshawk	*Accipiter gentilis*	WA	Candidate Species	
	Ferruginous Hawk	*Buteo regalis*	WA	Threatened	
	Golden Eagle	*Aquila chrysaetos*	WA	Candidate Species	
	Sage Grouse	*Centrocercus urophasianus*	WA	Threatened	Anticipated Candidate
	Sharp-tailed Grouse	*Tympanuchus phasianellus*	WA	Threatened	
	Marbled Murrelet	*Brachyramphus marmoratus*	WA	Threatened	Threatened
	Flammulated Owl	*Otus flammeolus*	WA	Candidate Species	
	Burrowing Owl	*Athene cunicularia*	WA	Candidate Species	
	Spotted Owl	*Strix occidentalis*	WA	Endangered	Threatened
	Vaux's Swift	*Chaetura vauxi*	WA	Candidate Species	
	Lewis's Woodpecker	*Melanerpes lewis*	WA	Candidate Species	
	White-headed	*Picoides albolarvatus*	WA	Candidate Species	

	Common Name	Scientific Name	State Status		Federal Status
	Woodpecker				
	Black-backed Woodpecker	*Picoides arcticus*	WA	Candidate Species	
	Pileated Woodpecker	*Dryocopus pileatus*	WA	Candidate Species	
	Loggerhead Shrike	*Lanius ludovicianus*	WA	Candidate Species	
	White-breasted Nuthatch	*Sitta carolinensis*	WA	Candidate Species	
	Sage Thrasher	*Oreoscoptes montanus*	WA	Candidate Species	
	Vesper Sparrow	*Pooecetes gramineus*	WA	Candidate Species	
	Sage Sparrow	*Amphispiza belli*	WA	Candidate Species	
		Total Listed Birds: 22			
Mammals					
	Merriam's Shrew	*Sorex merriami*	WA	Candidate Species	
	Townsend's Big-eared Bat	*Corynorhinus townsendii*	WA	Candidate Species	
	White-tailed Jackrabbit	*Lepus townsendii*	WA	Candidate Species	
	Black-tailed Jackrabbit	*Lepus californicus*	WA	Candidate Species	
	Western Gray Squirrel	*Sciurus griseus*	WA	Threatened	
	Northern Pocket Gopher	*Thomomys talpoides*	WA	Candidate Species	
	Gray Wolf	*Canis lupus*	WA	Endangered	Endangered
	Grizzly Bear	*Ursus arctos*	WA	Endangered	Threatened
	Fisher	*Martes pennanti*	WA	Endangered	
	Wolverine	*Gulo gulo*	WA	Candidate Species	
	Lynx	*Lynx canadensis*	WA	Threatened	Threatened
		Total Listed Mammals14			
Reptiles					
	Sharptail Snake	*Contia tenuis*	WA	Candidate Species	
	Striped Whipsnake	*Masticophis taeniatus*	WA	Candidate Species	
		Total Listed Reptiles: 2			
		Total Listed Species: 42			

IBIS 2003

Vegetative Groups

Vegetation in the Entiat subbasin (Figure 2) has been described over the years using a variety of methods. For example, one characterization emphasized vegetation important to grazing animals and identification of suitable range areas for range management analyses, while another characterization emphasized timber management interests by identifying stands with high commercial value.

The USFS identified vegetative groups on federal lands in the subbasin that had similar disturbance regimes. An approach comparable to that taken by Agee (1994) was used to delineate vegetation groups based on structure, general characteristics of the vegetation, tree species presence and tree canopy density. Designations also reflected a similarity in fire frequency and, to some extent, fire intensities and soil characteristics. The vegetative groups identified in the Watershed Assessment Entiat Analysis Area (USFS WNF 1996) are summarized below and in Table 7.

Table 7. Wildlife habitat types within the Entiat subbasin

Habitat Type	Brief Description
Montane Mixed Conifer Forest	Coniferous forest of mid-to upper montane sites with persistent snowpack; several species of conifer; understory typically shrub-dominated.
Eastside (Interior) Mixed Conifer Forest	Coniferous forests and woodlands; Douglas-fir commonly present, up to 8 other conifer species present; understory shrub and grass/forb layers typical; mid-montane.
Lodgepole Pine Forest and Woodlands	Lodgepole pine dominated woodlands and forests; understory various; mid- to high elevations.
Ponderosa Pine and Interior White Oak Forest and Woodland	Ponderosa pine dominated woodland or savannah, often with Douglas-fir; shrub, forb, or grass understory; lower elevation forest above steppe, shrubsteppe.
Subalpine Parkland	Coniferous forest of subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*) and lodgepole pine (*Pinus contorta*).
Alpine Grasslands and Shrublands	This habitat is dominated by grassland, dwarf-shrubland (mostly evergreen microphyllous), or forbs.
Eastside (Interior) Grasslands	Dominated by short to medium height native bunchgrass with forbs, cryptogam crust.
Shrubsteppe	Sagebrush and/or bitterbrush dominated; bunchgrass understory with forbs, cryptogam crust.
Agriculture, Pasture, and Mixed Environs	Cropland, orchards, vineyards, nurseries, pastures, and grasslands modified by heavy grazing; associated structures.
Urban and Mixed Environs	High, medium, and low (10-29 percent impervious ground) density development.
Open Water – Lakes, Rivers, and Streams	Lakes, are typically adjacent to Herbaceous Wetlands, while rivers and streams typically adjoin Eastside Riparian Wetlands and Herbaceous Wetlands
Montane Coniferous Wetlands	Forest or woodland dominated by evergreen conifers; deciduous trees may be co-dominant; understory dominated by shrubs, forbs, or graminoids; mid- to upper montane.
Eastside (Interior) Riparian Wetlands	Shrublands, woodlands and forest, less commonly grasslands; often multi-layered canopy with shrubs, graminoids, forbs below.

IBIS 2003

Shrubsteppe

This dry plant community is dominated by shrubs, grasses, or both. Tree canopy cover is less than 10 percent and tree species are ponderosa pine or sometimes Douglas-fir. Common and dominant shrubs are bitterbrush and sagebrush. Common grasses are bluebunch wheatgrass, junegrass, Sandberg's bluegrass, and bottlebrush squirreltail. In the Entiat, this group is found below the forest margin or on drier sites within forested areas at elevations of less than 4,500 feet.

Open Forest

This group is found mostly at lower elevations on relatively dry sites, commonly with grass or shrub understories similar to the Shrubsteppe Group. Typical tree canopy cover is 10-50% with grass/shrub cover of 10-90%. Ponderosa pine and Douglas-fir are the dominant tree species, with grand fir on some sites. These stands are essentially a transition between the shrubsteppe below and the closed forest above at elevations of less than 4,500 feet.

Closed Forest

Closed forest communities exhibit tree canopy covers of over 50%, with various understory species. This group is typically found at elevations between 1,500 and 4,000 feet; it may occur on north slopes at lower elevations and southerly aspects in the subalpine zone. Climax tree species are either Douglas-fir or grand fir; however, ponderosa pine and to a lesser extent lodgepole pine may temporally dominate some areas as a result of fire occurrence and frequency. This group combines fairly dry stands with relatively low site productivity and moist closed forest with fairly high site productivity.

Closed Subalpine

This group is typified by more than 50% tree canopy cover and various understory species. Communities are found between 4,500-6,000 feet, although this group can be found at lower elevations in cold air drainage areas and on north slopes. The predominant climax tree species in this group in the Entiat is subalpine fir. Lodgepole pine is the typical seral tree stand dominant.

Open Subalpine/Alpine

Open forest/park land interspersed with subalpine and alpine meadows typifies this group. Stands are generally open (canopy <50 percent) except in small clumps. Understory composition is commonly low shrubs, forbs, and graminoids. Conditions are often cold and snowy at the typical elevation range of this group (4,500-7,500 feet, with most over 6,000 feet). Common trees are subalpine fir, Englemann spruce, whitebark pine, and subalpine larch. Mountain hemlock may be present, but has limited distribution in the Entiat.

Table 8. Summary of vegetative groups found within the USFS Entiat Ranger District

Vegetation Type	Acres	Percent
Shrubsteppe	36,777	13.7
Open Forest	48,925	18.3
Closed Forest	109,936	41.0
Subalpine Forest	20,966	7.8
Open Subalpine	49,941	18.7
Non-vegetation (rock and/or water)	1,190	0.5
Total	267,735	100

CCCD 2004

Noxious Weeds

Several species of noxious weeds are found on both public and private lands within the Entiat subbasin. The most common noxious weeds include Dalmatian Toadflax, Canada thistle and Knapweeds, which are abundant in several locations throughout the subbasin. Knapweeds are especially prevalent along roads and other disturbed areas such as construction sites, gravel pits, utility and transportation corridors, as well as previously cultivated and/or semi-abandoned croplands and pastures. Some livestock pastures are heavily infested.

Proposed, Threatened, Endangered and Sensitive Plants

State and federal agencies maintain lists of proposed, threatened, endangered and sensitive plant species that occur or may occur within the Entiat subbasin. It is estimated that less than 50% of the subbasin has been surveyed, thus it is likely the lists are incomplete.

Wetlands

The USFWS National Wetlands Inventory (NWI) is the best existing information on wetlands in the Entiat subbasin. Table 9 provides a summary of the primary wetland systems and subsystems found within the subbasin. NWI data do not include all forested or seasonal wetlands, due to the mapping method used (high altitude aerial photography analysis). Wetlands are also dynamic, with plant communities and boundaries changing over time due to natural and human disturbances; thus, the accuracy of NWI data is limited.

An accurate assessment of historic and current wetlands distribution within the subbasin is difficult due a lack field data. The NRCS has collected some on the ground data during wetlands surveys, and the WDOE's Shorelands Environmental Assistance program staff also collects wetlands data within the subbasin. Information from the NRCS and WDOE will eventually be used to update the digital NWI wetland maps and data layers. A comprehensive, detailed inventory of wetland resources in the Entiat subbasin would provide information about the location of various wetland habitats and help identify potential restoration/enhancement areas.

Table 9. Primary wetland systems and subsystems found within Entiat subbasin

Definition	Approximate Acreage[+]
Lacustrine, limnetic, open water	2412
Lacustrine, littoral, unconsolidated bottom	23
Lacustrine, littoral, unconsolidated shore	6
Palustrine, emergent	514
Palustrine, forested	334
Palustrine, open water	71
Palustrine, shrub-scrub	546
Palustrine, unconsolidated shore	4
Riverine, upper perennial, open water	414
Riverine, upper perennial, unconsolidated shore	93
Upland	301,223
Total	305,640

CCCD 2004; USFWS NWI GIS data

3.2.6 Aquatic/Fish Resources

Many species of anadromous and non-anadromous fish utilize the aquatic habitat of the Entiat and Mad River watersheds. Some fish found in the subbasin are currently listed under the Endangered Species Act. Table 10 provides a summary of fish known and likely to occur in the subbasin, along with federally listed fish designations and candidate species which may be proposed for listing by the USFWS and/or NOAA Fisheries. The Washington Department of Fish and Wildlife maintains a state "Species of Concern" (SOC) list, which includes all *state* designated endangered, threatened, sensitive, and candidate species; state SOC list designations assigned to federally listed species are also provided.

Table 10.Summary of known and expected fish in the Entiat subbasin, and federal and state status

Species	Scientific Name	Federal ESA Listing and Date	State SOC Listing
Upper Columbia River late-run (summer) Chinook salmon	(Oncorhynchus tshawytscha)	---	---
Upper Columbia River spring Chinook salmon	(O. tshawytscha)	Endangered March 24, 1999	Candidate
Upper Columbia River summer steelhead	(O. mykiss)	Endangered August 18, 1997	Candidate
Sockeye salmon	(O. nerka)	---	---
Coho salmon	(O. kisutch)	---	---
Columbia River bull trout	(Salvelinus confluentus)	Threatened June 10, 1998	Candidate
Westslope cutthroat trout	(O. clarki lewisi)	Species of Concern	---
Redband trout[+]	(O. mykiss gardiner)	---	---
Brook trout	(S. fontinalis)	---	---
Mountain whitefish	(Prosopium williamsoni)	---	---
Longnose dace[+]	(Rhinichthys cataractae)	---	---
Mottled sculpin[+]	(Cottus bairdi)	---	---
Torrent sculpin	(C. rhotheus)	---	---
Largescale sucker	(Catostomus macrochelius)	---	---
Bridgelip sucker	(C. columbianus)	---	---
Pacific lamprey	(Entosphenus tridentatus)	Species of Concern	---
Northern pikeminnow	(Ptychocheilus oregonensis)	---	---
Redside shiner	(Richardsonius balteatus)	---	---

Note: Indicates expected presence based on information contained in the USFWS Entiat NFH Hatchery Genetic Management Plan and Mullan et al. 1992

In September 1994, NOAA Fisheries initiated a status review of late-run Chinook, sockeye, and Coho salmon to determine if listing was warranted. Although it was determined at that time that listing was not warranted, these three species should also be considered Candidate ESA species.

Anadromous Fish

Several populations of economically and culturally important anadromous fish species reside within the Entiat subbasin. The Entiat and Mad Rivers currently support runs of steelhead and bull trout, and spring and late-run Chinook salmon. Coho salmon were once present in the Entiat watershed (Mullan et al. 1992), but are now considered extinct (Nehlsen et al. 1991), however limited numbers of coho salmon reintroduced to the Wenatchee and Methow sub-basins, seem to be spawning in the Entiat River. The coho reintroduction efforts in the Wenatchee and Methow basin will likey expand to include the Entiat River in 2005. Coho reintroduction to the Enitat River is identified as a priority in the Wy-Kan-Ush-Mi-Wa-Kish-Wit document (Tribal Restoration Plan). Reintroduction methods would likely be similar to efforts in the Wenatchee and Methow sub-basins (Yakama Nation et. al. 2002). Sockeye salmon were also introduced into the Entiat River at one point. Notably, both Coho and Sockeye have recently been found utilizing the Entiat River (Hamstreet and Carie 2002, 2003). Upper Columbia River (UCR) spring Chinook salmon and summer steelhead trout are listed as endangered and Columbia River bull trout are listed as threatened under the Federal Endangered Species Act (ESA).

Dams constructed near the mouth of the Entiat River beginning in 1889 blocked salmon from returning to the Entiat to spawn. Barriers erected on Entiat River persisted through the mid-1930s, and probably contributed to the Coho's extinction (Craig and Suomela 1941). A Bureau of Fisheries survey of the Entiat in 1934, 1935 and 1936 showed the river was virtually devoid of salmon (Bryant and Parkhurst 1950) and salmon runs in general were essentially nonexistent by the time Grand Coulee Dam was built in 1939 (Craig and Suomela 1941).

As part of the Grand Coulee Fish Maintenance Project (GCFMP), all returning adult salmon were trapped at Rock Island Dam from 1939 to 1943. A total of 3,015 adult late-run Chinook were collected from commingled upper river stocks and placed in upper Entiat River spawning areas; only an estimated 1,308 of these survived to spawn (Fish and Hanavan 1948). Shorty Long recalls that fish were planted in two locations above the terminal moraine, at Burns Creek and Decker's near Gray Canyon. A weir was constructed at the terminal moraine to keep the adult salmon from migrating downstream to the Columbia River before spawning. Fish were also planted into Nason Creek and the Methow River, or spawned in hatcheries, including the Leavenworth, Winthrop and Entiat National Fish Hatcheries (NFH) (Fish and Hanavan 1948).

3.3 Scientific Conceptual Foundation

3.3.1 Definition and Overview of a Scientific Conceptual Foundation

A conceptual foundation is a set of scientific theories, principles and assumptions, which in aggregate describe how a system functions. The conceptual foundation determines how information is interpreted, what problems are identified and, as a consequence, it also determines the range of appropriate solutions (ISG 1996) to achieve desired management goals. It is through the conceptual foundation that management goals are translated into the conditions within the system that are needed to achieve those goals; and management strategies which could achieve the appropriate or desired conditions (NPPC 1997). The importance of the conceptual foundation is emphasized in the above citations, and most thoroughly discussed in "A Conceptual Foundation for the Management of Native Salmonids in the Deschutes River" (Lichatowich 1998). The latter forms the basis for much of the conceptual foundation of this Entiat Subbasin Plan.

3.3.2 Purpose and Scope

The conceptual foundation plays a powerful, albeit often unrecognized, role in natural resource management and restoration programs. It forms the premise and framework from which management goals and actions are based. Management goals should be achievable within the logical framework of the conceptual foundation and conditions within the ecosystem should relate to each other in ways which are specified in the logical framework. Managers need to recognize and clearly describe the implications of strategies derived from our conceptual foundation.

Laws and policies typically form the basis for many management plans. Often, these are based on a set of theories, premises or simply ideas which in whole define a conceptual foundation. Although these theories or premises guide the development and implementation of a program, rarely are they explicitly stated. As long as the conceptual foundation remains unstated it cannot be reviewed, evaluated and debated in open forums. False assumptions, outdated science, unsupported principles and unintended consequences in the conceptual foundation cannot be identified and corrected unless they are explicitly stated and publicly discussed.

A conceptual foundation must address ecosystems at various scales. Clear definitions of ecosystems are always problematic because ecosystem function occurs at various temporal and spatial scales simultaneously. For example, organisms are a product of their native environment, but just as importantly, many environments are products of certain species and populations. Species like anadromous salmonids use many ecosystems and are very sensitive to environmental changes. Changes in one ecosystem, such as the ocean can change salmonid abundance in the freshwater environments, which in turn can alter environmental conditions for other organisms.

The focus and organization of the assessment, inventory, and management strategies of a subbasin plan should directly reflect the conceptual foundation. The foundation should also consider the increasingly broader geographic scales within which other fish and wildlife management plans or actions operate. For example, in the Columbia Basin, this means that the way the conceptual foundation views events at the smallest scale—the individual fish and its surrounding habitat—should be consistent with and mirror how the fish communities and habitat characteristics are viewed at the river reach scale, subbasin tributary, entire subbasin, multiple subbasins or regional scale (e.g., Evolutionary Significant Unit (ESU) scale), and aggregate Columbia basin anadromous fish stocks in the estuary and ocean environments. Ensuring conceptual consistency across multiple geographic scales in the management and recovery of fish, wildlife, and their habitats is a daunting challenge which has yet to be fully realized—primarily because the conceptual foundation at each geographic level is not explicitly stated and there has not been adequate communication and coordination regarding scientific principles and assumptions between the ever increasing numbers of management entities and governmental boundaries (i.e., local, state, and national) as geographic scale increases.

The conceptual foundation is defined at the largest geographic scale applicable to a planning effort. In this case, the Columbia Basin will usually be the largest geographic scale, although other out of basin scales may be appropriate for some migratory birds and the saltwater life stage of anadromous fish. As the plan focuses with increasing detail on management strategies for smaller geographic areas, subbasin planners should then continue to check for conceptual consistency. The only current examples of an explicitly stated conceptual foundation are the "alternative conceptual foundations" of *Return to the River* and the NPCC's An Integrated Framework for Fish and Wildlife Management in the Columbia Basin (NPPC 1997), which are reviewed and synthesized in Lichatowich (1998).

3.3.3 Guiding Principles

Four sets of guiding principles, in bold and shaded derived from Lichatowich's (1998) synthesis in the Columbia Basin Conceptual Foundation introduce principles and corollaries relevant to the Entiat subbasin. These four guiding principles have been modified to make them applicable to both fish and wildlife. Following them are principles pertaining to the Entiat Subbasin Conceptual Foundation.

The Columbia River is a natural-cultural system characterized by natural environmental variability and fluctuation in production. Salmon restoration and management must consider the whole ecosystem, natural as well as cultural, in the freshwater, estuary, and ocean. Suitable ecosystem attributes can be achieved by managing human interference in the natural habitat forming processes and by use of technology to support those processes. The use of technology to circumvent natural ecological processes should be avoided, if possible.

Principle 1. Strategies for recovery or maintenance of viable populations need to be evaluated within the context of the entire life history of the populations.

The Entiat Subbasin Plan can only identify, evaluate and prioritize alternative strategies for anadromous and migrating species recovery that can be fully implemented within the subbasin by authorized local, state, federal and tribal managers. The subbasin plan addresses strategies that can be implemented locally and that effect life stages that subbasin managers can influence or control through their decisions. However, planning and implementing actions for fish and wildlife within the Entiat subbasin must also consider out of basin affects, which will influence the success or failure of population recovery.

Ideally, populations should be tracked or accounted for throughout the geographical range of their life history to ensure that differential survival/mortality rates specific to that population can be evaluated in preparation of management or recovery strategies.

For species whose entire life history is confined to the Entiat Subbasin, it is possible to make informed and logical decisions regarding all strategies necessary for management. For fish and wildlife species that spend a portion of their life history outside of the subbasin boundaries, management goals, the desired ecosystem attributes, and restoration strategies should generally be universal and integrated across the subbasin, eco-region (ESU), Columbia Basin, and full life history including estuary and marine scales to be successful. Where differing parts of a population's life history or habitat are managed by different entities, those populations and their interactions with the environment, with other populations, and their responses to management actions should be monitored and communicated in a common language. The broader and more inclusive the management planning process becomes, the greater the potential that these common and integrated goals, attributes, strategies will be successful in recovering far-ranging migratory species.

Principle 2. The Entiat Subbasin contains an evolving, natural-cultural system that will continue to change into the future.

The Entiat subbasin's natural and cultural elements must be considered in any management planning. Unless a balance between the needs and constraints of the natural and cultural components of the ecosystem is achieved, the status of many of the native fish and wildlife populations in the basin will continue to decline. To move toward a balance, science and resource managers need to present the values and benefits of the natural elements and must show when their benefits outweigh the costs of protection and recovery. In addition, it must be made clear that healthy natural and cultural elements are not mutually exclusive.

Principle 3. Important environmental attributes that determine the distribution and productivity of fish and wildlife populations have been influenced by human activity in and outside the subbasin.

Cultural impacts have occurred at different rates and to varying degrees throughout the subbasin. For example the transportation system along the mainstem Entiat River, agricultural land use practices and channel modifications for flood control have directly altered floodplain, riparian, and in-channel characteristics to a large degree. These changes undoubtedly have affected habitat use and the relationship many of these species once had to these effected areas.

Many habitat attributes, now out of synch or timing with the life history strategies that fish and wildlife populations had evolved prior to those alterations, may be lethal to fish or wildlife for part of the year, or have directly resulted in habitat loss. These alterations have resulted in decreased abundance and productivity, and changes in the distribution of native fish and wildlife populations.

Fish and wildlife productivity requires a network of complex, interconnected habitats that are created, altered, and maintained by natural physical processes in terrestrial, freshwater, estuary, and ocean areas. Management and restoration goals depend on achieving suitable ecosystem attributes.

Principle 4. Viable native fish and wildlife populations are dependent upon the natural environment and the natural processes that sustain them.

Discovering which of the natural processes most influence various populations is fundamental to management direction. Usually the original conditions represent the best models we will ever have. Subbasin planners and managers must avoid a common tendency to become excessively or exclusively species-centric in developing management strategies. Instead, focusing on restoring terrestrial and aquatic/riparian ecosystem health and function will provide habitat attributes that will enable holistic management or recovery for larger assemblages of native biota.

Principle 5. Changes to the physical characteristics and connectivity of the Entiat subbasin have contributed to the decline of native fish and wildlife populations.

Understanding the pre-development conditions, the current conditions, the trend in these conditions, and their effect on ecosystem attributes is crucial to formulation of recovery strategies. Throughout much of the Entiat subbasin, management and recovery of fish and wildlife productivity requires an emphasis on restoration of the natural range of hydrological attributes and fluvial processes, reconnection of isolated physical habitat, and protection or reintroduction of populations once reconnection has been achieved.

Principle 6. Changes to the physical characteristics of the alluvial valley and floodplains of the Entiat River have resulted in changes in ecosystem attributes.

Changes to the physical characteristics of the alluvial valley and floodplains of the Entiat River have resulted in changes in relatively large-scale ecosystem attributes. Some of these changes are reversible from a societal perspective; some are not. Floodplain management and restoration where possible is a key to successful recovery of physical and biological characteristics that support native fish and wildlife species.

Principle 7. The historical distribution of fish and wildlife populations and species in the Entiat Subbasin was controlled by relatively abrupt changes in physical attributes, i.e. steep environmental gradients.

In the Entiat subbasin, examples of environmental gradients existed at:

- Mouths of the lakes (thermal control or feeding stations for bull trout)
- Presence of lakes (refuge for cutthroat)
- Stream temperature (segregation of species)
- Stream gradients (slope) (provision to habitat types more conducive to certain species or life stages)
- Aspect, elevation or precipitation-based changes in vegetation zones (such as the forest/shrub steppe interface)

Changes to or elimination of the environmental gradients are expected to affect the presence and distribution of species or populations. Not all species respond in the same way to a similar gradient. Increasing the summer water temperature and lowering the winter temperature would have a powerful effect on aquatic species distribution and life history. Similarly, reducing the quality and quantity of "edge effects" from vegetative interfaces can significantly reduce habitat diversity required for many species to thrive.

Species diversity and the biotic community are a reflection of the ecosystem attributes. The co-evolved assemblage of species share requirements for similar ecosystem attributes and those attributes can be estimated by intensive study of focal or indicator species.

Principle 8. For aquatic and fish related interests, selection of a broad range of focal species provide a basis for developing holistic management strategies. For terrestrial and wildlife related interests, the selection of focal habitats and related focal species provide a basis for developing holistic management strategies.

Bull trout, cutthroat trout, spring chinook, late-run chinook, steelhead, and Pacific lamprey are the aquatic focal species for the Entiat subbasin. Through evaluating and planning for these species we assume that viable and sustainable ecosystem function and processes occurs in most geographic areas for important floodplain and riverine associated habitats.

In the case of terrestrial wildlife, focal habitat types can often be characterized by vegetation patterns. By maintaining adequate quality, quantity and connectivity of key vegetative communities we assume that viable and sustainable habitats are available and ecosystem function occurs over a wide range of the focal species. Ponderosa pine forests and woodlands, shrub-steppe and riparian habitats are the terrestrial focal habitats which cover most of the mid and low elevation areas within the subbasin.

Viability, a key concept in the context of conservation planning, refers to the ability of a species or a community/ecological system referred to in this document as focal habitats to persist over some specified time period. Species viability at the population level is affected by chance events that may dictate whether a species remains viable or goes extinct. Three general factors characterize community or ecological systems viability:

- demography of component species populations
- internal processes and structures among these component species
- landscape level processes that sustain the community or system

These factors are often referred to as size, condition, and landscape context.

Principle 9. The scientific concept of environmental stress is a legitimate means to evaluate the degree to which a threat to an environment by natural or human induced stressors may result in significant and undesired ecologic changes or the vulnerability of an environment to those stressors.

Environmental stressors such as an altered fire regime, rapid spread of invasive species or pathogens or altered habitat composition can affect environmental conditions at relatively small and large scales. Environmental stressors operate on habitat size and condition as well as landscape-scale attributes. The sources of these stresses are both natural and human-caused. Understanding the causes and likelihood of environmental stressors provides for long-term perspective of how future environmental conditions may relate to long-term management goals. The combination of stresses and sources provides a deeper analysis of potential viability impairment, thus forming a basis for management strategies.

Principle 10. Fish and wildlife are components of their own environment.

Inter and intra-specific competition are the drivers for species abundance, fitness and life history diversity within a given species assemblage. Restoration of individual populations may not be possible without restoration of other fish or wildlife populations with which they co-evolved. Beyond direct relationships between various populations, fish and wildlife alter key habitat characteristics (e.g., nutrients, cleaned spawning beds, beaver ponds, forest understory, etc.) which can directly and indirectly affect other species/populations by changing important environmental characteristics.

Life history, genetic diversity, and metapopulation organization are ways that fish and wildlife adapt to their habitat. Diversity and population structure are how fish and wildlife species cope with spatial and temporal environmental variations. Such diversity promotes production and long-term persistence at the species level.

Principle 11. Most native fish and wildlife populations are linked across large areas which decrease the possibilities for extinctions or extirpations. An important component for recovery of depressed populations is to work within this framework and maintain or recreate large-scale spatial diversity.

Attempting to maintain or restore populations outside a framework of large-scale spatial diversity will be difficult or impossible. Management of Entiat subbasin fish and wildlife populations in the wild and in the hatchery environment should include strategies to maintain a close connection to the ecosystem attributes that influence and shape the population (i.e., environmental selective pressures), while also allowing for gene flow across populations. Any program to restore fish and wildlife to the Entiat subbasin must be capable of detecting and monitoring new, locally adapted life histories, if and when they occur in unique habitats.

Reintroduction or supplementation programs for fish or wildlife should concentrate on specific environments within the basin, selection of an appropriate stock for reintroduction to that environment or locally adapting a donor stock where a local stock no longer exists. When supplementing native populations, the facilities and programs should mimic the native environment as closely as possible. For example, in the hatchery environment, this includes maintenance of life history diversity such as spawn timing, matching hatchery incubation temperatures to the natural incubation environment, and simulating the natural rearing environment in the hatchery to the extent feasible.

Population management using supplementation must consider habitat quality and quantity to determine if existing habitat has the carrying capacity to support the number of fish or wildlife needed for genetic expression and to meet population goals.

Principle 12. Populations with the least amount of change from their historic spatial diversity are the easiest to protect and restore, and will have the best response to restoration actions.

The ability to predict population responses to changes in the environment is highest for those populations that are closest to their pre-settlement population structure. At some point along the scale from intact populations to former populations that have had entire metapopulation (groups of related populations that share genes at low rates over time) extirpated from the basin and adjacent basins, emphasis on recovery actions is better focused on rebuilding population structure than on habitat restoration. If the goal of cost- effective restoration is to be achieved, subbasin planners need to assess the optimal mix of habitat restoration and population structure restoration to achieve biological goals.

Populations that have multiple life histories (e.g., multiple locations or times where rearing takes place, multiple ages/times of year when out-migration occurs, multiple ages at sexual maturity, multiple spawning areas) minimize risk to the population as a whole. These life history strategies are linked to population structure and genetics.

Principle 13. All else being equal, small populations are at greater risk of extinction than large populations, primarily because several processes that affect population dynamics operate differently in small populations than they do in large populations.

In some cases, small populations will need measures in addition to habitat protection and/or restoration if they are to survive into the future. Such measures may include specific forms of artificial production (broodstock collection programs for supplemented salmonid populations), artificial introduction from outside the population, or special consideration where habitat alterations or restoration modifies the only known sites where a particular life history is expressed.

3.3.4 Foundations for Current Understanding

The topography and drainage pattern of the Entiat River sub-basins were formed by volcanism, glaciation and uplift. Thus, much of the stream channel matrix consists of massive bedrock outcroppings, rock fall, and materials left over from glaciation too large to be moved by natural stream flows of today. Streambed materials consists mainly of sand, gravel and cobble from the glaciated upper valley, and angular stones and silty-clay from tributary basins and valley walls in the lower valley. In general, streams within the Entiat sub-basin are classified as non-erodible, and relatively high gradient and/or entrenched (Rosgen F, B and A channel types). A notable exception to the general classification is the Stillwater reach of the middle-Entiat River which passes through a terminal moraine. The moraine provides a large supply of sand, gravel and small cobble which can be transported by natural stream flows of today. The Entiat River within the Stillwater area is a low gradient, meandering stream with erodible banks (Rosgen C channel type) and currently supplies the primary spawning and rearing areas for anadromous salmonids.

During the past few hundred years, erosional processes associated with climate, wild fire and activities of Euro-Americans have had the primary influence on watershed and stream corridor conditions. Climate is the primary factor causing rock fall, highly variable streamflow and wild fire. Wild fire and floods cause episodic sediment and debris loading of the stream system. Development within the past 100 years have increased background erosion rates in portions of the watershed, and confined, simplified and straightened much of the lower river channel.

Floods following wild fire are common natural events in the Entiat sub-basin that deliver large volumes of sediment and debris to the stream system. Debris fans are common at the mouths of tributary streams. It appears that an adequate supply of material is being delivered to the stream system to support natural channel building processes within the lower ten to fifteen miles of the Entiat River. However, active processes are only observed in the lower mile.

Because of the watersheds climate, topography, and limited degree of development, natural physical processes are dominant at the watershed scale. Floods, wild fires and natural erosion remain the primary disturbance factors even though much of the lower Entiat valley is occupied by orchards and rural residential farms.

At a stream segment scale, the legacy of Euro-American resource extraction activity constrains the proper functioning of natural river processes and directly effects the biological characteristics of specific locations in the stream system. These activities include trapping of beaver, grazing, road construction, logging, water impoundment, and river channel modification for flood control. Present day activities (water diversion, rural residential and agricultural development) effect flood plain and river terrace vegetation, but have little effect on stream channel characteristics.

The most pronounced influence of Euro-American activities occurs along the lower ten miles of the Entiat River and lower mile of the Mad River. The lower ten miles of the Entiat River was channelized and diked in response to 1948 flooding. The lower mile of the Mad River has been confined by a former lumber mill and work camp.

In both locations the stream channel is relatively straight, has a uniform slope and cross section, and is disconnected from its former flood plain. As a result, streambed shear stress is higher and more uniform over the streambed than would naturally occur. Little opportunity exists today for sand or gravel to be deposited within the activity channel, and the streambed is well armored. In a natural state, channel alignment would be more sinuous and depth of flow would be more variable. In some locations over bank flow during flood events would be common. The natural channel geometry would result in a non-uniform distribution of streambed shear force and local deposition of sand and gravel. Woody debris jams would also be expected.

The removal of large wood and debris jams from the Entiat River has affected gravel deposition and streambed topography between River mile 10 and 17. United States Bureau of Fisheries surveys during the 1930's report several debris jams pools in this reach. Today this reach is void of channel complexity being classified as a long, continuous run or riffle.

Today, the good land stewardship being practiced by many private land owners along the lower Entiat River and the large degree to which natural processes function throughout the watershed provide a solid foundation for undertaking stream restoration work in the lower ten to seventeen miles of the Entiat River. The spring and summer run chinook and steelhead would benefit from well focused stream channel enhancements and in some cases restoration.

The primary focus of this restoration work should be on increasing the complexity of streambed topography, developing depositional sites for spawning gravel, and reconnecting the river to its flood plain and over flow channels. Collectively these actions will provide more diversity in depth of flow and streambed shear. Existing natural river processes will work with the restored channel features to provide transient gravel deposits, a more defined thalweg, low velocity zones and off channel habitats. Both adult and juvenile life phases are expected to benefit from the envisioned stream restoration work.

4 The Assessment

4.1 Introduction

A focal species will be used to evaluate the health of the ecosystem and the effectiveness of management actions. Focal habitat types are used as the basis for the wildlife assessment. Fish focal species were defined that a) have special cultural significance, b) fulfill a critical ecological function, c) serve as an indicator of environmental health, d) are locally significant or rare as determined by applicable state or federal resource management agencies and/or are federally listed species.

Because wildlife species often are wide ranging and typically have varied habitat needs, key focal habitats were used as bio-indicators and several different species that are obligated to these habitats were selected for this evaluation. The three focal habitats and representative species selected for this evaluation are listed below.

Table 11. Wildlife focal habitats and their representative species within the Entiat subbasin

Focal Habitats	Wildlife Species Represented
Shrubsteppe	Sharp-tailed grouse, Grasshopper sparrow, Brewer's sparrow, Mule deer
Ponderosa – Mixed Hardwood	White-headed woodpecker, Pygmy nuthatch, Flammulated owl, Grey flycatchers
Riparian	Red-eyed vireo, Yellow-breasted chat, Beaver

Six anadromous and resident fish species were chosen as focal species. Each of these species is considered to be culturally important, three of the species are listed under the ESA and each species uniquely represent different and important habitat characteristics. The six species and their representative habitat types are listed below.

Table 12. Fish focal species and their representative habitats within the Entiat subbasin

Focal Fish Species	Habitats Represented
Spring Chinook	Mid elevation tributary streams, stream order 2-3.
Late-run Chinook	Mid and lower Entiat River mainstem
Coho	Lower-mid elevation mainstem and tributaries
Steelhead	Lower–mid elevation mainstem and tributaries
Pacific Lamprey	Undefined habitat, culturally important species.
Bull trout	Mid-upper elevation tributaries
Cutthroat trout	Upper elevation, higher gradient tributaries.

4.1.1 Terrestrial/Wildlife Methodology, Species and Habitat Selection

Methodology

The wildlife assessment was developed from a variety of "tools" including subbasin summaries, the Interactive Biodiversity Information System (IBIS), WDFW Priority Habitats and Species

(PHS) database, Washington GAP Analysis database, Partners in Flight (PIF) information, National Wetland Inventory maps, Ecoregion Conservation Assessment (ECA) analyses, and input from local state, federal, and tribal wildlife managers. Specific information about these data sources is located in Appendix A

Although IBIS is a useful assessment tool, it should be noted that the historic habitat maps have a minimum polygon size of 1 km^2 while current IBIS wildlife habitat maps have a minimum polygon size of 250 acres (T. O'Neil, NHI, personal communication, 2003). In either case, linear aquatic, riparian, wetland, subalpine, and alpine habitats are under-represented, as are small patchy habitats that occur at or near the canopy edge of forested habitats. It is also likely that micro habitats located in small patches or narrow corridors were not mapped at all. Another limitation of IBIS data is that they do not reflect habitat quality nor do they associate habitat elements (key ecological correlates [KECs]) with specific areas. As a result, a given habitat type may be accurately depicted on IBIS map products, but may be lacking quality and functionality. For example, IBIS data do not distinguish between shrubsteppe habitat dominated by introduced weed species and pristine shrubsteppe habitat. Washington State GAP data were also used extensively throughout the wildlife assessment. The GAP-generated acreage figures may differ from IBIS acreage figures as an artifact of using two different data sources. The differences, however, are relatively small (less than five percent) and will not impact planning and/or management decisions.

The ECA spatial analysis is a relatively new terrestrial habitat assessment tool developed by The Nature Conservancy (TNC). The ECA has not been completed in all areas within the greater Columbia River Basin. Where possible, however, WDFW integrated ECA outputs into Province/ subbasin plans. The major contribution of ECA is the spatial identification of priority areas where conservation strategies should be implemented. ECA products were reviewed and modified as needed by local wildlife area managers and subbasin planners.

Focal Representative Habitats

Focal representative habitats selected for the subbasin include ponderosa pine, shrubsteppe, and riparian wetlands. Neither the IBIS nor the Washington GAP analysis data recognize the historic presence of riparian wetlands. The current extent of this habitat type as reflected in these databases is suspect at best; however, riparian wetland habitat is a high priority habitat wherever it is found in the ecoprovince. Agriculture, a habitat of concern, is not included as a focal habitat type at the subbasin level. Focal wildlife habitat types are fully described in Appendix A.

Wildlife Focal Species

The focal species selection process is described in Appendix A. Province and subbasin planners identified focal species assemblages for each focal habitat type (Table 11).

Focal habitats selected for the subbasin include ponderosa pine, shrubsteppe, and riparian wetlands. Neither the IBIS nor the Washington GAP Analysis data recognize the historic presence of riparian wetlands. The current extent of this habitat type as reflected in these databases is suspect at best; however, riparian wetland habitat is a high priority habitat wherever it is found in the Province. Agriculture, a habitat of concern, is not included as a focal habitat type at the subbasin level.

Table 11. Focal species selection matrix for the Columbia Cascade Province

Common Name	Focal Habitat[1]	Status[2]		Native Species	PHS	Partners in Flight	Game Species
		Federal	State				
Sage thrasher	SS	n/a	C	Yes	Yes	Yes	No
Brewer's sparrow		n/a	n/a	Yes	No	Yes	No
Grasshopper sparrow		n/a	n/a	Yes	No	Yes	No
Sharp-tailed grouse		SC	T	Yes	Yes	Yes	No
Sage grouse		C	T	Yes	Yes	No	No
Pygmy rabbit		E	E	Yes	Yes	No	No
Mule deer		n/a	n/a	Yes	Yes	No	Yes
Willow flycatcher	RW	SC	n/a	Yes	No	Yes	No
Lewis woodpecker		n/a	C	Yes	Yes	Yes	No
Red-eyed vireo		n/a	n/a	Yes	No	No	No
Yellow-breasted chat		n/a	n/a	Yes	No	No	No
American beaver		n/a	n/a	Yes	No	No	Yes
Pygmy nuthatch	PP	n/a	n/a	Yes	No	No	No
Gray flycatcher		n/a	n/a	Yes	No	No	No
White-headed woodpecker		n/a	C	Yes	Yes	Yes	No
Flammulated owl		n/a	C	Yes	Yes	Yes	No

[1] SS = Shrubsteppe; RW = Riparian Wetlands; PP = Ponderosa pine;
[2] C = Candidate; SC = Species of Concern; T = Threatened; E = Endangered

Ashley and Stovall 2004

Six bird species and two mammalian species were selected to represent three priority habitats in the Subbasin. Life requisite habitat attributes for each species assemblage were pooled to characterize a "range of management conditions", to guide planners in development of future habitat management strategies, goals, and objectives.

General habitat requirements, limiting factors, distribution, population trends, and analyses of structural conditions, key ecological functions, and key ecological correlates for individual focal species are included in Ashley and Stovall (unpublished report, 2004). The reader is further encouraged to review additional focal species life history information in Appendix A.

Establishment of conditions favorable to focal species will benefit a wider group of species with similar habitat requirements

4.2 Terrestrial/Wildlife Assessment

Areas Currently Under Protection Status

An estimated 25,130 acres (8 percent) are permanently protected in the Entiat Subbasin. These lands have permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events of natural type are allowed to proceed without interference or are mimicked through management (high protection). Approximately 1.3 percent (3,926 acres) of the Subbasin has permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state (medium protection status). The majority of lands in the Subbasin (221,978 acres; 74 percent) has permanent protection from conversion of natural land cover for the majority of the area, but is subjected to uses of either a broad, low intensity type or localized intense type (low protection status). Approximately 16 percent (47,329 acres) of the lands within the Subbasin lack irrevocable easements or mandates to prevent conversion of natural habitat types to anthropogenic habitat types (no protection). Lands owned by WDFW fall within the medium and low protection status categories.

Additional habitat protection, primarily on privately owned lands, may be provided through the Conservation Reserve Program (CRP) and the Conservation Reserve Enhancement Program (CREP). The CRP is intended to reduce soil erosion on upland habitats through establishment of reduce stream sedimentation and provide protection for riparian/riverine habitats using buffer strips comprised of herbaceous and woody vegetation.

Both programs provide short-term (CRP-10 years; CREP-15 years), high protection of habitats enrolled in either program. The U.S. Congress authorizes program funding /renewal, while the USDA determines program criteria. Program enrollment eligibility and sign-up is decentralized to state and local NRCS offices (R. Hamilton, FSA, personal communication, 2003).

Vegetation

Subbasin vegetation, wildlife habitat descriptions, and changes in habitat quantity, distribution, abundance, and condition are summarized in the following sections. Landscape level vegetation information is derived from the Washington GAP Analysis Project (Cassidy 1997) and IBIS data (2003).

Rare Plant Communities

The Subbasin contains 22 rare plant communities. Approximately 32 percent of the rare plant communities are associated with shrubsteppe habitat, and 68 percent with upland forest habitat.
Noxious Weeds

Changes in biodiversity have been closely associated with changes in land use. Grazing, agriculture, and accidents have introduced a variety of exotic plants, many of which are vigorous enough to earn the title noxious weed. Twenty-one species of noxious weeds occur in the Subbasin.

Vegetation Zones

Cassidy (1997) identified seven historic (potential) vegetation zones that occur within the Subbasin. The three-tip sage, central arid steppe, and ponderosa pine vegetation zones are described in detail in Ashley and Stovall (unpublished report, 2004). These vegetation zones constitute focal habitat types. Douglas-fir, grand fir, subalpine fir, and alpine parkland are not focal habitat types, but these vegetation zones occur extensively throughout the Subbasin.

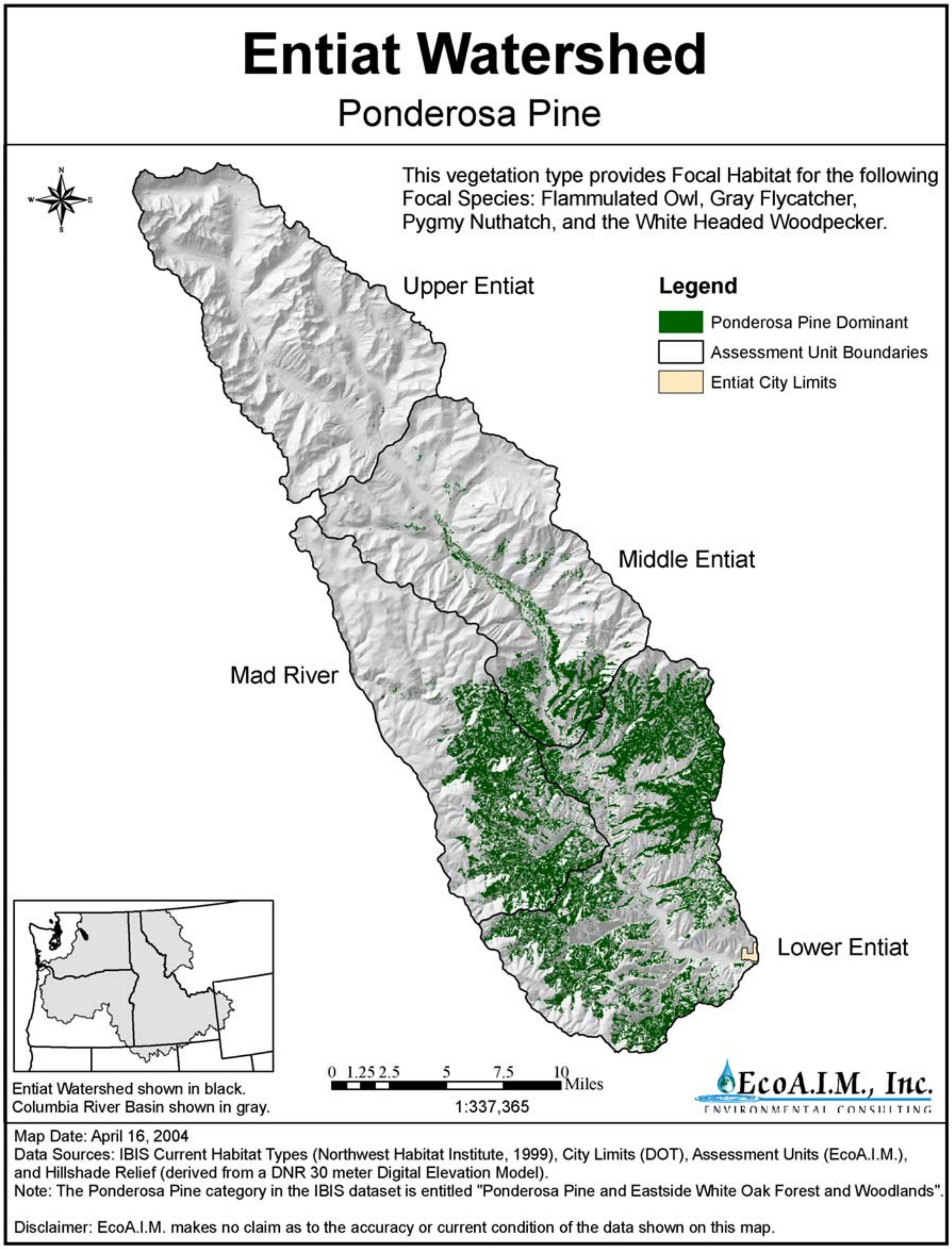


Figure 4. Ponderosa pine distribution in the Entiat subbasin

4.3 Ponderosa Pine

Historically in the Subbasin, old-growth ponderosa pine forests occupied areas between the shrubsteppe zone and moister forest types at higher elevations. Large, widely spaced, fire-resistant trees and an understory of forbs, grasses, and shrubs characterized these forests. Periodic fires maintained this habitat type. With the settlement of the Subbasin, most of the old pines were harvested for timber, and frequent fires have been suppressed. As a result, much of the original forest was replaced by dense second growth of Douglas-fir and ponderosa pine with little understory.

Extant ponderosa pine habitat within the Subbasin currently covers a wide range of seral conditions. Forest management and fire suppression have led to the replacement of old-growth ponderosa pine forests by younger forests with a greater proportion of Douglas-fir than pine stands (Wright and Bailey 1982). The best available information characterizing subbasin habitats is found in US Forest Service watershed assessments (USFS 1995, 1996). Approximately 24% of the subbasin is open forest habitat type (63,000 acres), including ponderosa pine habitat. Much of this habitat type in the subbasin was burned in severe, stand-replacing fires in 1988 and 1994, which burned approximately 29% of the subbasin. These areas lack live tree overstories.

Large late-seral ponderosa pine and Douglas-fir have been harvested in much of this habitat type. In combination with fire suppression, effects of these harvests have resulted in decreased tree size; increased tree density; decreased patch size; and decreased connectivity (USFS 1995, 1996).

Introduced annuals, especially cheatgrass and invading shrubs under historic heavy grazing pressure, have invaded or replaced native herbaceous understory species, particularly on low, dry sites. Four exotic knapweed species *(Centaurea* spp.*)* are spreading rapidly through the ponderosa pine zone and threatening to replace cheatgrass as the dominant increaser after grazing (Roche and Roche 1988). Dense cheatgrass stands have changed the fire regime of these stands often contributing to stand replacing, catastrophic fires.

Primary cavity excavator habitat (PCE) is important for many species of wildlife and is part of the functioning of an ecosystem. PCE habitat consists of standing dead trees, or live defective standing trees that provide cavities or potential cavities for vertebrates. Species such as Lewis woodpecker and flammulated owl prefer dead trees in open grassy conditions. Stands of well-spaced, large old trees with their fire scars, large broken-out limbs, dead sections and snags provide cavities for roosts and nests, insects to feed on, and water (springs, ponds, streams, and wetlands) for flammulated owls and bats. Additionally, dead downed trees provide cover, food, and dens for snowshoe hares, chipmunks, voles, ground squirrels, shrews, and others (USFS 1996 in NPPC 2002).

The 1970 fires in this drainage burned many thousands of acres and most big trees were salvaged. An examination of this fire area now shows almost no snags and the new trees are 2-6 inches in diameter. In other words, these acres no longer contain primary cavity excavator habitat. Some of this fire area burned again in 1988 (Dinkleman fire) and 1994 (Tyee fire), leaving the area with no standing dead trees and no down logs to provide any potential habitat (USFS 1996 in NPPC 2002).

It appears that PCE habitat may be below established levels over large areas of the Subbasin. This is a major problem in the lower elevations and in areas that have been burned by fires. Higher elevations and burned areas may have acceptable levels. Large areas will be devoid of standing and down PCE habitat for 50 – 100 years. This function will not completely return to these stands for 200-400 years (USFS 1996 in NPPC 2002).

Introduced annuals, especially cheatgrass and invading shrubs under heavy grazing pressure, have replaced native herbaceous understory species. Four exotic knapweed species *(Centaurea* spp.*)* are spreading rapidly through the ponderosa pine zone and threatening to replace cheatgrass as the dominant increaser after grazing (Roche and Roche 1988). Dense cheatgrass stands eventually change the fire regime of these stands often resulting in stand replacing, catastrophic fires. Bark beetles, primarily of the genus *Dendroctonus* and *Ips*, kill thousands of pines annually and are the major mortality factor in commercial saw timber stands.

Protection Status

The protection status of ponderosa pine habitat for subbasins within the Province is compared in Appendix A of this document. The protection status of remaining ponderosa pine habitat in all subbasins fall primarily within the "low" to "no protection" status categories. As a result, this habitat type will likely suffer further degradation, disturbance, and/or loss in all Province subbasins. Protection status of ponderosa pine habitat within the Subbasin is illustrated in Table 12.

Table 12. Ponderosa pine habitat GAP protection status in the Entiat subbasin

GAP Protection Status	Acres
High Protection	11
Medium Protection	545
Low Protection	43,248
No Protection	12,008

IBIS 2003

Factors Affecting Ponderosa Pine Habitat

Factors affecting ponderosa pine habitat are explained in detail in Appendix A and are summarized below:

- Timber harvesting, particularly at low elevations, has reduced the amount of old growth forest and associated large diameter trees and snags.
- Urban and residential development has contributed to loss and degradation of properly functioning ecosystems.
- Fire suppression/exclusion has contributed towards habitat degradation, particularly declines in characteristic herbaceous and shrub understory from increased density of small shade-tolerant trees. High risk of loss of remaining ponderosa pine overstories from stand-replacing fires due to high fuel loads in densely stocked understories.
- Overgrazing has resulted in invasion of exotic plants, resulting in altered understory conditions and increased fuel loads.

- Fragmentation of remaining tracts has negatively impacted species with large area requirements.
- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and may be subject to high levels of human disturbance.
- Timber harvesting, particularly at low elevations, has reduced the amount of old growth forest and associated large diameter trees and snags.
- Urban and residential development has contributed to loss and degradation of properly functioning ecosystems.
- Fire suppression/exclusion has contributed towards habitat degradation, particularly declines in characteristic herbaceous and shrub understory from increased density of small shade-tolerant trees. High risk of loss of remaining ponderosa pine overstories from stand-replacing fires due to high fuel loads in densely stocked understories.
- Overgrazing has resulted in invasion of exotic plants, resulting in altered understory conditions and increased fuel loads.
- Fragmentation of remaining tracts has negatively impacted species with large area requirements.
- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and may be subject to high levels of human disturbance.

Ponderosa Pine Community

4.3.1 White-headed Woodpecker

The white-headed woodpecker represents species that require/prefer large patches (greater than 350 acres) of open mature/old growth ponderosa pine stands with canopy closures between 10–50% and snags (a partially collapsed, dead tree) and stumps for nesting (nesting stumps and snags grater than 31 in. in diameter at breast height (DBH). Abundant white-headed woodpecker populations can be present on burned or cut forest with residual large diameter live and dead trees and understory vegetation that is usually very sparse. Openness however, is not as important as the presence of mature or veteran cone producing pines within a stand.

The pygmy nuthatch represents species that require heterogeneous stands of ponderosa pine with a mixture of well-spaced, old pines and vigorous trees of intermediate age and those species that depend on snags for nesting and roosting, high canopy density, and large diameter (greater than 18 in. DBH) trees characteristic of mature undisturbed forests. Connectivity between suitable habitats is important for species, such as pygmy nuthatch, whose movement and dispersal patterns are limited to their natal territories.

4.3.2 Flammulated Owl

Flammulated owls represent wildlife species that occupy ponderosa pine sites comprised of multiple-canopy, mature ponderosa pine stands or mixed ponderosa pine/Douglas-fir forest interspersed with grassy openings and dense thickets. Flammulated owls nest in habitat types with low to intermediate canopy closure, two layered canopies, tree density of 508 trees/acre (9-ft. spacing), basal area of 250 sq. ft./acre, and snags greater than 20 in. diameter at breast height (DBH) and 3-39 ft. tall. Food requirements are met by the presence of at least one snag greater than 12 in. DBH/10 acres and 8 trees/acre greater than 21 in. DBH.

4.3.3 Gray Flycatchers

Gray flycatchers represent wildlife species that occupy the pine/shrubsteppe interface (pine savannah) with a shrub/bunchgrass understory. Gray flycatchers require nest trees 18 in. DBH and a tree height of 52 ft. for their reproductive life requisites.

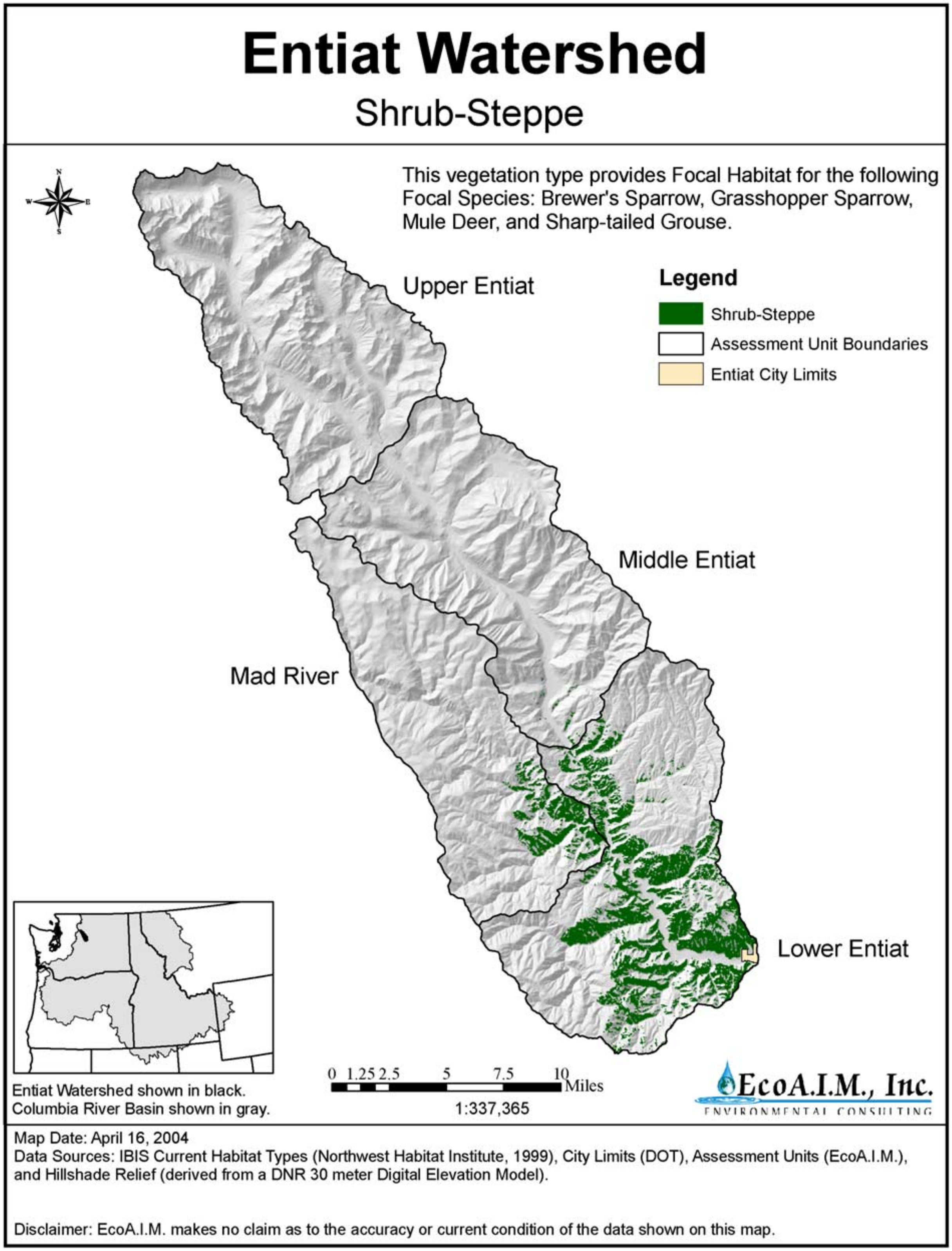


Figure 5. Shrubsteppe distribution in the Entiat subbasin

4.4 Shrubsteppe

The greatest changes in shrubsteppe habitat from historic conditions are the reduction of bunchgrass cover in the understory and an increase in sagebrush cover. Soil compaction is also a significant factor in heavily grazed lands affecting water percolation, runoff and soil nutrient content. A long history of grazing, fire, and invasion by exotic vegetation has altered the composition of the plant community within much of the extant shrubsteppe in this region (Quigley and Arbelbide 1997; Knick 1999), and it is difficult to find stands which are still in relatively natural condition.

Fire has relatively little effect on native vegetation in the three-tip sagebrush zone, since three-tip sagebrush and the dominant graminoids resprout after burning. Three-tip sagebrush does not appear to be much affected by grazing, but the perennial graminoids decrease and are eventually replaced by cheatgrass (*Bromus tectorum*), plantain *(Plantago* spp.), big bluegrass (*Poa secunda),* and/or gray rabbitbrush (*Chrysothamnus nauseosus).* In recent years, diffuse knapweed (*Centaurea diffusa)* has spread through this zone and threatens to replace other exotics as the chief increaser after grazing (Roche and Roche 1998).

In areas of central arid steppe with a history of heavy grazing and fire suppression, true shrublands are common and may even be the predominant cover on non-agricultural land. Most of the native grasses and forbs are poorly adapted to heavy grazing and trampling by livestock. Grazing eventually leads to replacement of the bunchgrasses with cheatgrass, Nuttall's fescue (*Festuca microstachys*), eight flowered fescue (*F. octofiora),* and Indian wheat (*Plantago patagonica*) (Harris and Chaney 1984). In recent years, several knapweeds (*Centaurea spp*.), have become increasingly widespread.

Historically, sage dominated steppe vegetation occurred throughout the majority of the lower elevations in the Entiat subbasin as variations of shrubsteppe habitat once occupied most of the non-forested land in eastern Washington. The moister draws and permanent stream courses imbedded in the shrubsteppe landscape supported strands of riparian vegetation dominated by moisture loving shrubs and small trees, including thick stands of water birch, a major component of the winter diet of sharp-tailed grouse. The drastic reduction of water birch in the Subbasin by early settlers is likely a major factor in the extirpation of sharp-tailed grouse (NPPC 2002).

Shrubsteppe and open forest habitat are preferred by deer in winter and by the other species throughout the year. Deer winter range once covered about 100,000 to 200,000 acres in the lowlands and extended across the Columbia River. Prior to construction of the Rocky Reach Dam, water was lower and the channel was narrower in winter. Small wetlands, meadows and riparian areas along streams, springs and adjacent forests provided deer and other wildlife with good thermal cover essential to cold, severe winters (USFS 1996 in NPPC 2002).

Today, only 56,000 acres of winter range still exist. Reduced winter range size is attributed to a number of factors: 1) the Rocky Reach Dam /Rock Island hydroelectric facility commenced operation in 1961, flooding much of the low elevation winter habitat and preventing access to available habitat across the river; 2) the 1994 Tyee fire eliminated about 70 percent of the cover and forage provided in the winter range; 3) grazing and development (agricultural and residential) favor invasion by noxious weeds, diminishing the deer's native forage base of grasses and forbs; 4) roads constructed to accommodate timber harvest, development, and winter recreation (cross country skiing, hunting, and snowmobiling) have fragmented habitat and increased the number of deer killed by motorists (USFS 1996 in NPPC 2002).

Protection Status

The protection status of shrubsteppe habitat for province subbasins is compared in Appendix A of this document. The protection status of remaining shrubsteppe habitats in all subbasins fall primarily within the "low" to "no protection" status categories. As a result, this habitat type will likely suffer further degradation, disturbance, and/or loss in all province subbasins. Protection status of shrubsteppe habitat within the Entiat subbasin is illustrated in Table 13.

Table 13. Shrubsteppe habitat GAP protection status in the Entiat subbasin

GAP Protection Status	Acres
High Protection	0
Medium Protection	2,331
Low Protection	17,066
No Protection	13,586

IBIS 2003

Factors Affecting Shrubsteppe Habitat

Factors affecting shrubsteppe habitat are explained in detail in Appendix A and are summarized below:

- Permanent habitat conversions of shrubsteppe/grassland habitats (e.g., approximately 60 percent of shrubsteppe in Washington [Dobler *et al.* 1996]) to other uses (e.g., agriculture, urbanization)
- Fragmentation of remaining tracts of moderate to good quality shrubsteppe habitat
- Degradation of habitat from past intensive grazing and invasion of exotic plant species, particularly cheatgrass, knapweeds and Dalmatian toadflax
- Degradation and loss of properly functioning shrubsteppe/grassland ecosystems resulting from the encroachment of urban and residential development and conversion to agriculture. Best sites for healthy sagebrush communities (deep soils, relatively mesic conditions) are also best for agricultural productivity; thus, past losses and potential future losses are great. Most of the remaining shrubsteppe in Washington is in private ownership with little long-term protection (57 percent).
- Loss and reduction of cryptogamic crusts, which help maintain the ecological integrity of shrubsteppe/grassland communities
- High density of nest parasites (brown-headed cowbird) and domestic predators (cats) may be present in hostile/altered landscapes, particularly those in proximity to agricultural and residential areas subject to high levels of human disturbance.

- Agricultural practices that cause direct or indirect mortality and/or reduce wildlife productivity. There are a substantial number of obligate and semi-obligate avian/mammal species; thus, threats to the habitat jeopardize the persistence of these species.
- Fire management, either suppression or over-use
- Invasion and seeding of crested wheatgrass and other introduced plant species which reduces wildlife habitat quality and/or availability

Shrubsteppe Community

4.4.1 Mule Deer

Mule deer were selected to represent species that require and prefer diverse, dense (30 to 60% shrub cover less than 5 ft. tall) shrubsteppe habitats comprised of bitterbrush, big sagebrush, rabbitbrush, and other shrub species with a palatable herbaceous understory exceeding 30% cover.

4.4.2 Brewer's Sparrow

Brewer's sparrow was selected to represent wildlife species that require sagebrush dominated sites. Brewer's sparrow prefers a patchy distribution of sagebrush clumps, 10-30% cover, lower sagebrush height (between 20 and 28 in.), 1981), 10 to 20% native grass cover, less than 10% non-native herbaceous cover, and bare ground greater than 20%. It should be noted, however, that shrublands comprised of snowberry, hawthorne, chokecherry, serviceberry, bitterbrush, and rabbitbrush were also used by Brewer's sparrows for nesting in southeast Washington. Specific, quantifiable habitat attribute information for this mixed shrub landscape could not be found.

4.4.3 Sharp-tailed Grouse

Sharp-tailed grouse was selected to represent species that require multi-structured fruit/bud/catkin producing deciduous trees and shrubs dispersed throughout the landscape (10 to 40% of the total area). Other habitat conditions include:

- Native bunchgrass greater than 40% cover
- Native forbs at least 30% cover
- Visual obstruction readings (VOR) at least 6 in. least 75% cover deciduous shrubs and trees
- Exotic vegetation/noxious weeds less than 5% cover

4.4.4 Grasshopper Sparrow

Grasshopper sparrow was selected to represent species that require healthy steppe habitat dominated by native bunch grasses. Grasshopper sparrow require native bunchgrass cover greater than 15% and comprising greater than 60% of the total grass cover.

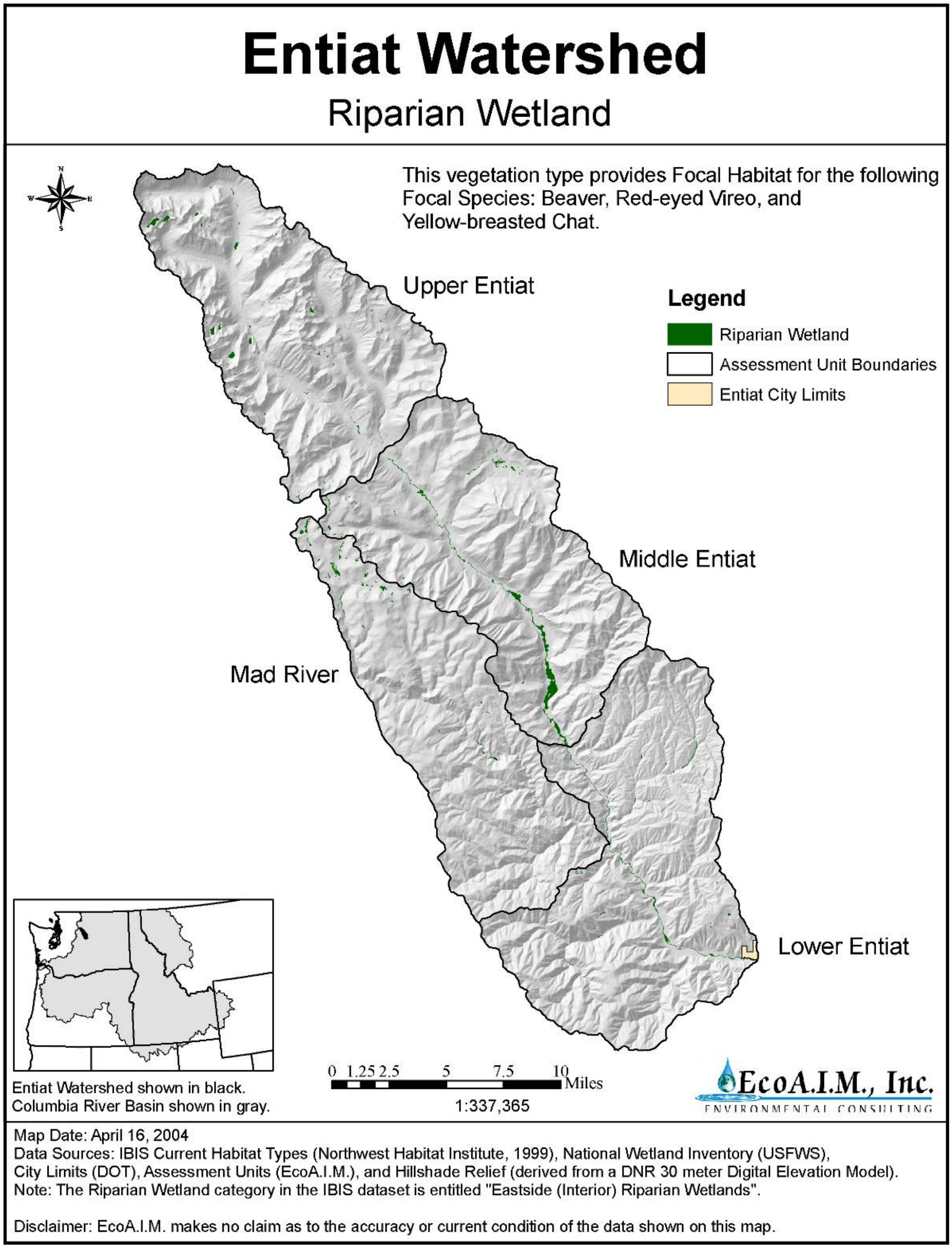


Figure 6. Riparian composition in the Entiat subbasin

4.5 Eastside (Interior) Riparian Wetlands

The eastside (interior) riparian wetlands habitat type refers only to riverine and adjacent wetland habitats in both the province and individual subbasins. Historic (circa 1850) and, to a lesser degree, current data concerning the extent and distribution of riparian wetland habitat are a significant data gap at both the province and subbasin level. The lack of data is a major challenge as province and subbasin planners attempt to quantify habitat changes from historic conditions and develop strategies that address limiting factors and management goals and objectives.

Due to the lack of historic riparian wetland data, the IBIS database cannot be relied upon for comparisons in the province and individual subbasins between the historic and current extent of riparian wetlands. According to the IBIS database (2003), there are an estimated 3,898 acres of riparian wetland habitat currently in the Subbasin. Although there are no historic data, the actual number of acres or absolute magnitude of the change is less important than recognizing the loss of riparian habitat and the lack of permanent protection continues to place this habitat type at further risk.

Historically, riparian wetland habitat was characterized by a mosaic of plant communities occurring at irregular intervals along streams and dominated singularly or in some combination by grass-forbs, shrub thickets, and mature forests with tall deciduous trees. Beaver activity and natural flooding are two ecological processes that affected the quality and distribution of riparian wetlands.

Today, agricultural conversion, altered stream channel morphology, and water withdrawal have played significant roles in changing the character of streams and associated riparian areas. However, the Entiat subbasin is still host to some of eastern Washington's best remaining tracts of cottonwood gallery forests, found in the floodplain portions of the Subbasin. Large areas once dominated by cottonwoods, which contribute considerable structure to riparian habitats, are being lost. Because of its proximity to roads and other developed areas, much of the remaining riparian/floodplain habitat may be at risk of conversion to housing development.

Many species found in the riparian zone are the same as those inhabiting the adjacent uplands. The water and abundance of food in the riparian zone attracts these species. Acre for acre, riparian areas are more productive than the surrounding land. Some species, such as the water shrew, dipper, amphibians, some bats, many invertebrates and plants, are riparian obligates. An obligate species may not spend its whole life in a particular habitat, but it needs riparian habitat at some time in its life cycle for survival or reproduction.

Riparian conditions within the Entiat can be separated into three zones: 1) transport zone (headwaters and alpine/subalpine communities), 2) forested mountain slopes (transitional zone), and 3) depositional zone (shrubsteppe and open forest). Riparian vegetation in the transport zone consists of grand fir, Engelmann spruce, Douglas-fir, lodgepole pine, red cedar, cottonwood, grasses, and forbs. An estimated 6.6 miles of road are located within 300 feet of a stream channel in this zone and road densities are below 1.0 mile/mi^2 (CCCD 1999 in NPPC 2002). Riparian area impacts at developed campgrounds in this zone are localized and minimal, except for the concentrated use at Cottonwood Campground. Riparian zone function is good to excellent (CCCD 1999 in NPPC 2002).

Riparian vegetation in the transitional zone consists of cottonwood, red cedar, grand fir, with dogwood and alder in lower elevations, and the addition of Engelmann spruce and western hemlock in higher elevation reaches. There are 43 miles of road located within 300 feet of stream channel in this zone. Riparian zone function is fair to excellent (CCCD 1999 in NPPC 2002).

Riparian vegetation in the depositional zone consists primarily of deciduous species with alder, willow, cottonwood, aspen, elderberry, red osier dogwood, river birch, maple, and conifers (i.e., ponderosa pine and Douglas-fir) being the dominant species. In some reaches, loss of vigorous shrubs in the riparian zone has reduced instream organic input, reduced shade, and contributed to unstable stream banks and associated erosion. There are a total of 205 miles of road located within 300 feet of a stream in this zone. Many roads are native surface with minimal surface water control features. Stream adjacent roads and associated management have reduced large woody debris recruitment. Riparian zone function is poor to good (CCCD 1999 in NPPC 2002).

Overall, the trend in riparian habitat conditions is toward fewer riparian areas due to dams, grazing, trapping of beaver, forest fires, and other anthropogenic activities. The Rocky Reach Dam flooded productive bottomland. Although grazing has been reduced significantly from historical levels, there may still be some local areas of impacts in the Subbasin. Streambanks are destabilized, erosion and water temperatures have increased, water quantity and quality is diminished, soils are compacted, vegetation is altered and destroyed, and channel hydrology, morphology, and instream structure are altered (USFS 1996 in NPPC 2002).

While riparian habitats are temporarily destroyed by catastrophic events, such as the Tyee fire that burned 32 percent of the Subbasin in 1994, these events can be beneficial by retarding succession to primary stages. This in turn creates habitat diversity within the riparian zone. Beaver are apt to benefit from early and mid-successional stages as the stands recover (USFS 1996 in NPPC 2002).

The current extent of riparian wetland habitat throughout the Columbia Cascade Province is illustrated in Appendix A of this document.

Protection Status

The protection status of riparian habitat is compared by subbasin in Appendix A of this document. The vast majority of province riparian habitat is designated low or no protection status and is at risk for further degradation and/or conversion to other uses. The GAP protection status of riparian wetland habitat in the Subbasin is depicted in Table 14.

Table 14. Eastside riparian wetlands GAP protection status in the Entiat subbasin

GAP Protection Status	Acres
High Protection	0
Medium Protection	0
Low Protection	17
No Protection	77

IBIS 2003

Factors Affecting Eastside (Interior) Riparian Wetland Habitat

Factors affecting riparian wetland habitat are described in Appenix A and summarized below:

- Loss of habitat due to numerous factors including riverine recreational developments, inundation from impoundments, cutting and spraying of riparian vegetation for eased access to water courses, gravel mining, etc
- Habitat alteration from 1) hydrological diversions and control of natural flooding regimes (e.g., dams) resulting in reduced stream flows and reduction of overall area of riparian habitat, loss of vertical stratification in riparian vegetation, and lack of recruitment of young cottonwoods, ash, willows, etc., and 2) stream bank stabilization which narrows stream channel, reduces the flood zone, and reduces extent of riparian vegetation
- Habitat degradation from livestock overgrazing which can widen channels, raise water temperatures, and reduce understory cover.
- Habitat degradation from conversion of native riparian shrub and herbaceous vegetation to invasive exotics such as reed canary grass, purple loosestrife, perennial pepperweed, salt cedar, indigo bush, and Russian olive
- Fragmentation and loss of large tracts necessary for area-sensitive species such as yellow-billed cuckoo
- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and be subject to high levels of human disturbance.
- High energetic costs associated with high rates of competitive interactions with European starlings for cavities may reduce reproductive success of cavity-nesting species such as Lewis' woodpecker, downy woodpecker, and tree swallow, even when outcome of the competition is successful for these species
- Recreational disturbances (e.g., ORVs), particularly during nesting season, and particularly in high-use recreation areas

Riparian Community

4.5.1 Red-eyed Vireo

Red-eyed vireo was selected to represent species that require greater than 60% canopy closure. For their food and reproductive requirements red-eyed vireo require mature deciduous trees greater than 160 ft. tall. Greater than 10% of the shrub layer should be young cottonwoods.

4.5.2 American Beaver

Beaver were selected to represent species that require 40-60% tree/shrub canopy closure and shrub height greater than 6.6 ft. Beavers also require trees less than 6 in. DBH.

4.5.3 Yellow-breasted Chat

Yellow-breasted chat were selected to represent species that require riparian habitat with a shrub layer 3-13 ft. tall, 30-80% shrub cover, scattered herbaceous openings, and less than 20% tree cover.

The change in extent of the riparian wetland habitat type from c.1850 to 1999 is not included because of inaccurate IBIS (2003) data and geographic information system (GIS) products.

4.6 Agriculture

Because agriculture is not a focal wildlife habitat type and there is little opportunity to effect change in agricultural land use at the landscape scale, subbasin planners did not conduct an analysis of agricultural conditions.

Agricultural development in the Entiat subbasin has altered or destroyed native shrubsteppe habitat and fragmented riparian/floodplain habitat. Agricultural operations have increased sediment loads and introduced herbicides and pesticides into streams. Conversion to agriculture has decreased the overall quantity of habitat for many native species, but the loss of specific communities may be particularly critical for habitat specialists.

Although the preceding information is described, reliable quantification of effects at the subbasin level is lacking.

Protection Status

The IBIS (2003) data clearly indicate that nearly all of this cover type has no protection status within the Entiat subbasin. Small amounts of agricultural lands, however, are given low and medium protection status. Low and medium protection is limited to lands enrolled in conservation easements, or those that are under other development restrictions such as county planning ordinances.

Table 15. Agriculture GAP protection status in the Entiat subbasin

GAP Protection Status	Acres
High Protection	0
Medium Protection	692
Low Protection	2,098
No Protection	5,044

IBIS 2003

4.7 Summary of Factors Affecting Focal Habitats and Focal Species

It is highly unlikely that the extent of shrub-steppe and riparian wetland and herbaceous habitats is now greater than what occurred historically in the province, as indicated by IBIS. IBIS data indicate a 55% reduction in ponderosa pine habitat from historic within the subbasin, but there is little reason to consider this an accurate quantification of this loss. Subbasin planners have little confidence in IBIS data at the subbasin level. For additional information regarding focal habitat changes throughout the ecoregion, see Appendix A.

Habitat data are incomplete and limited in value. Accurate habitat type maps, especially those detailing riparian and herbaceous wetland habitats, are needed to improve assessment quality and support management strategies/actions. Subbasin wildlife managers, however, believe that significant physical and functional losses have occurred to focal habitats from timber management, hydroelectric facility construction and inundation, agricultural, urban and residential development, fire suppression, livestock grazing and the spread of noxious weeds.

Since 1850, a number of human induced physical changes have redefined the quality and quantity of terrestrial habitat found in the mid and lower portions of the Subbasin. The most significant among these changes is habitat fragmentation compounded by degradation in overall habitat quality resulting from historic and current agricultural practices, timber management, mismanaged grazing, and commercial and residential development activities (NPPC 2002). Combinations of these activities have contributed to 1) alteration, reduction, and elimination of riparian habitat; 2) alteration and elimination of floodplains; 3) increased road densities and related erosion as well as loss of canopy cover; and 4) changes to overall vegetative composition and forage availability in both riparian and upland areas.

Agriculture

Agricultural development in the Entiat subbasin has altered or destroyed native shrubsteppe habitat and fragmented riparian/floodplain habitat. Agricultural operations have increased sediment loads and introduced herbicides and pesticides into streams. Conversion to agriculture has decreased the overall quantity of habitat for many native species, but the loss of specific communities may be particularly critical for habitat specialists.

Although the preceding information is described, reliable quantification of effects at the subbasin level is lacking.

Timber Management

Timber management activities, including extensive timber harvest in sections of the Entiat subbasin, have resulted in the widescale removal of large ponderosa pine trees between 1880 and the 1960s (USFS 1995, 1996). There is a lack of all forested vegetation types in excess of 24” DBH in the open forest type (USFS 1995). As a result of historical selective harvest in the ponderosa pine series, in addition to stand-replacing fires attributed to effects of fire suppression, large diameter, late successional habitat of this type is lacking in the basin. This removal is believed to have subsequently reduced populations of dependent wildlife species, as well as snag dependent species in some areas. Logging has contributed to fragmentation of habitat, soil erosion, sediment delivery to creeks and streams, and changes to upland and riparian vegetative communities, including displacement of native plant communities with exotic species.

Although the preceding information is described, reliable quantification of effects at the subbasin level was lacking.

Livestock Grazing

Livestock grazing has negatively affected wildlife habitat in the Subbasin. In 1971, a cooperative agreement was reached between the Washington Department of Game, Entiat Valley Stockman’s Association, and the Forest Service, to reduce grazing pressure in the Johnson Creek, Oklahoma Gulch, and Entiat Breaks in exchange for use in the Mud and Potato Creek drainages. The purpose of this agreement was to benefit conditions for mule deer on crucial winter ranges. Due to valley bottom overuse and excessive, detrimental grazing impacts in riparian zones, pastures in lower Mud and Potato Creeks were closed in summer 1993 (USFS 1995). Additionally, invasion by exotics, primarily cheatgrass and knapweed, is attributed primarily to historic overgrazing (USFS 1995).

Although the preceding information is described, reliable quantification of effects at the subbasin level was lacking.

Commercial and Residential Development

While urban areas comprise only a small percentage of the land base within the Subbasin (0.1 percent), their habitat impacts are significant. Residential growth within the Subbasin is largely occurring along creeks and rivers. Channelization and development along water courses has eliminated riparian and wetland habitats. Expansion of residential areas affects drainage, and homes built along streams have affected both water quality and the ability of the floodplain to function normally. Residential development has resulted in the loss of large areas of all focal habitat types. Disturbance by humans in the form of highway traffic, noise and light pollution, and various recreational activities have the potential to displace wildlife and force them out of their native areas or forces them to use less desirable habitat.

The conversion of forested uplands and riparian habitat to residential use has negatively affected wildlife habitat connectivity and composition. Road construction and dispersed residential development have impeded stream access and changed vegetative communities, resulting in the reduction of wildlife range and quality. Human activities have increased the number of fire starts, but historic fire control policies have kept the size of fires small, resulting in a buildup of fuel in the forested uplands of the Subbasin. This absence of fire has resulted in changes to the composition of the forest and plant communities, and the related capacity to store and transport water.

Although the preceding information is described, reliable quantification of effects at the subbasin level was lacking.

Fire

Fire is a dominant agent of change in this subbasin. Management attempts to influence ecosystem processes such as fire have had widespread and significant effects on the condition of wildlife habitat throughout the area, resulting in decreased habitat for some species and increased habitat for others. Fire suppression in conjunction with past management practices has created unnatural vegetation patterns. Forested stand conditions on north/northeast facing slopes developed a higher number of smaller (pole-sized) stems per acre of Douglas-fir, lodgepole pine and *ceanothus*, causing the canopy to be more closed than would naturally have occurred. The bitterbrush component had increased on south/southeast facing slopes where grasses were more prominent than they are today (USFS 1998 in NPPC 2002). In 1988 and 1994, stand-replacing wildfires occurred on large areas of the subbasin, including the majority of ponderosa pine and shrub-steppe habitats. These fires likely resulted from plural effects of invasion by noxious weeds, past fire suppression and efforts, timber management practices.

Although the preceding information is described, reliable quantification of effects at the subbasin level was lacking.

Beaver trapping

Historic harvest eliminated beaver from much of the subbasin, resulting in decreases in riparian wetland habitat (USFS 1995).

Hydropower Development and Operation

In 1961, completion and operation of the Rocky Reach dam and hydroelectric project on the Columbia River inundated significant amounts of riparian and shrub-steppe habitat, resulting in: reductions in habitat quality and quantity relative to historic conditions; altered development of riparian habitats, and is impacting shoreline and backwater erosion and sedimentation.

Subbasin-specific effects are not quantified.

Noxious Weeds

Noxious weeds are prevalent in the lower Entiat Basin. Most focal habitats are located in the lower basin, and noxious weeds are nearly ubiquitous in focal habitats. Livestock grazing, development, timber management, recreation, and fire management all have played a role in the current noxious weed situation. Quantification is lacking at the subbasin level.

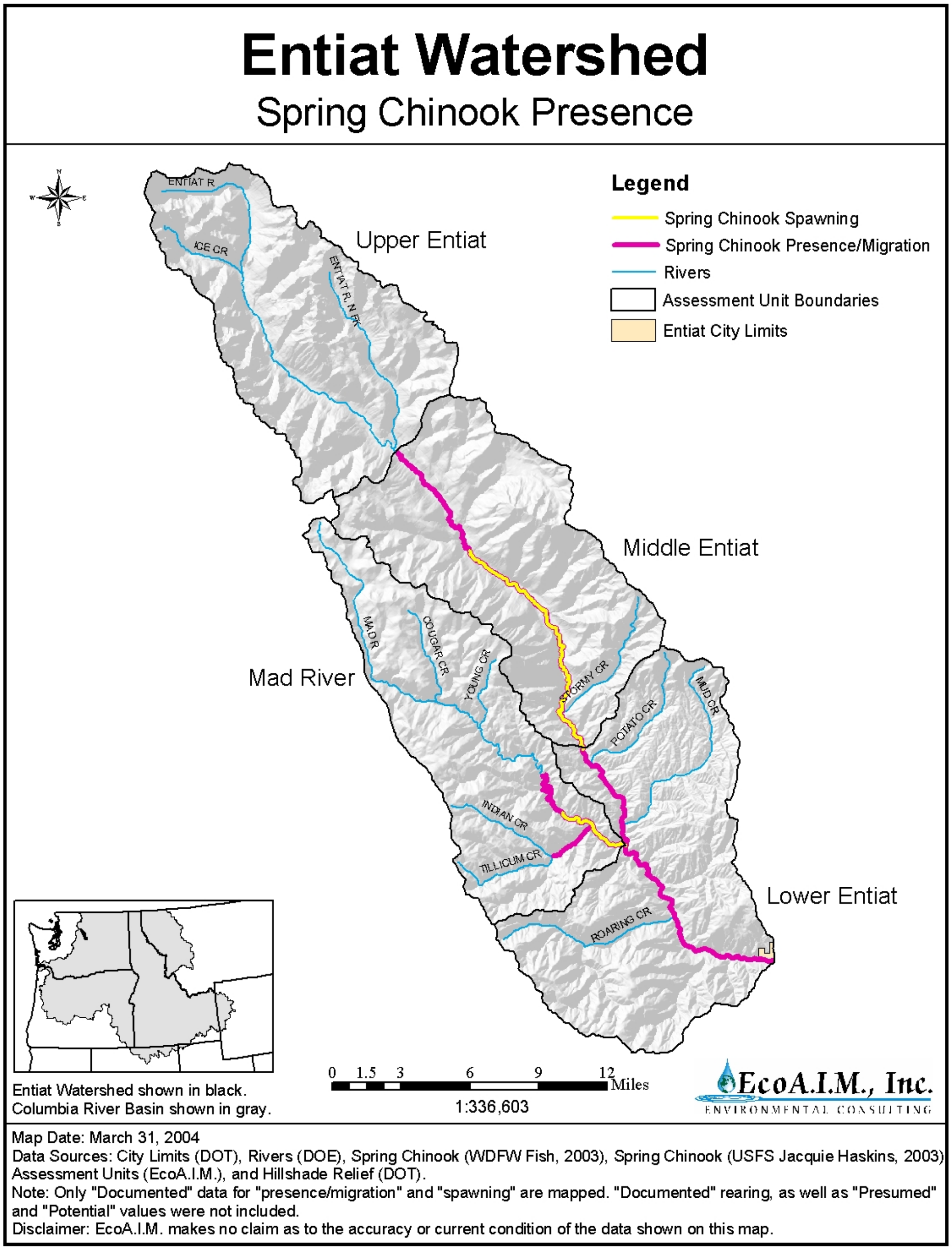


Figure 7. Spring chinook distribution in the Entiat subbasin

4.8 Aquatic/Fish Assessment

4.8.1 Fish Focal Species

Six anadromous and resident fish species were chosen as focal species. Spring chinook, late-run chinook, coho, steelhead, Pacific lamprey, bull trout, and cutthroat trout.

4.8.2 Spring Chinook (*Oncorhynchus tshawytscha*)

Rationale for Selection

Spring chinook salmon (stream type) are considered depressed throughout most of their current range and many stocks are at danger of extinction. All remaining populations and habitats are considered to be vital to the continued persistence of chinook salmon in the interior Columbia basin.

The Entiat spring chinook is included by NOAA Fisheries into the Upper Columbia ESU and listed as an endangered under the ESA. Spring chinook salmon utilize most of the lower Entiat subbasin and are sensitive to many environmental conditions and changes. Spring chinook provide a good biological indicatory of ecosystem health for the lower and middle reaches of the Entiat River.

Key Life History Strategies, Relationship to Habitat

Time of entry and spawning

Adult spring chinook begin entering the Entiat River basin in May. Spawning begins in very late July through September, peaking in mid- to late August (Chapman et al. 1995 CPa). The onset of spawning in a stream reach is temperature driven (usually when temperatures drop below 16 °C). Temperature may be influenced by riparian conditions. Land use within the Entiat and Mad rivers has affected riparian areas, conservation of remaining areas of riparian and restoration of riparian areas will increase production for many life stages.

Prespawning

Adults hold in the deeper pools and under cover of the mainstem Entiat or Mad rivers. The availability of and number of deep pools and cover is important to offset potential prespawning mortality. Intact riparian habitat will increase the likelihood of instream cover, and normative channel geofluvial processes will increase the occurrence of deeper pools.

Redd characteristics

Important habitat needs for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. Healy (1991) reports the range of depths of spawning as between 41 to > 700 cm (~1-23 ft) and velocities of between 10 to 150 cm/s (.33-5 ft/s) for chinook salmon (this includes ocean-type chinook too). Preservation or restoration of naturally occurring geofluvial function insures that the proper spawning habitat is available.

Incubation and emergence

Healy (1991) reports that incubation and emergence success was related to oxygen levels and percolation through the gravel. When percolation was 0.03 cm/s (0.001 ft/s), survival to hatching was 97%. However, emergence reduced to 13% when percolation was 0.06 cm/s (0.002 ft/s). When oxygen fell below 13 ppm, mortality of eggs increased from 3.9% at 13 ppm to about 38% at 5 ppm.

Stream conditions (e.g., frequency of flooding, extreme low temperatures) may affect egg survival too. Floods can scour eggs from the gravel by increasing bedload movement. High flows associated with unstable stream banks increases sediment deposition that reduces oxygen and percolation through the redd. Healy (1991) cites Shaw and Maga (1943) as showing that siltation may be more lethal earlier in the incubation period than in later phases. Overall, Healy (1991) reports that spawning to emergence ranged from 40-100% (these estimates include ocean-type chinook too).

In the Entiat Basin, fall flooding has a high frequency of occurrence. This may negatively affect incubation and emergence success, especially in years of extreme flows (e.g., 1990 and 1995). Road building activities in the upper watersheds may also increase siltation, as well as grazing and mining activities. All three factors were once more prevalent than they are now in the basin, and conditions have improved in most watersheds.

Fry

Spring chinook fry utilize near-shore areas, primarily eddies, within and behind large woody debris, undercut tree roots, or other cover (Hillman et al. 1989a; Healy 1991). Conservation and restoration of riparian areas of natal streams within the Entiat Basin would increase the type of habitat that fry utilize.

Parr

Downstream movement of parr from natal streams is well documented. French and Wahle (1959) found that juvenile chinook migrated past Tumwater Dam on the Entiat River (RM 33) from spring through late fall. Since 1992, sampling by WDFW has found spring chinook emigrating from the Chiwawa River as pre-smolts from late summer through the fall. In general, movement from the Chiwawa River included some yearlings leaving as early as March, extending through May, followed by subyearlings leaving through the summer and fall (until trapping ceases because of inclement weather; A. Murdoch, WDFW, personal communication). A similar movement of parr probably occurs in the Entiat River.

Movement of juvenile chinook from the higher-order streams in the fall appears to be a response to the harsh conditions encountered in the upper tributaries. Bjornn (1971) related subyearling chinook movement in an Idaho stream indirectly to declining temperature in the stream as fish try to find suitable overwintering habitat. Hillman and Chapman (1989) suggested that biotic factors, such as intraspecific interaction for available habitat with naturally- and hatchery- produced chinook, nocturnal sculpin predation, and interspecific interactions may accelerate movement of subyearlings from the mainstem Entiat River. This may or may not be true of the areas of the Entiat River which produce most of the spring chinook in that basin. Hillman et al. (1989) related subyearling chinook movement from an Idaho stream to declining temperatures, but acknowledged that it may consist of fish seeking higher-quality winter habitat, as suggested by Bjornn (1971).

Mullan et al. (1992) found most of the chinook rearing in Entiat river miles 3-6. In the Entiat River during the daytime, juvenile chinook used instream and overhead cover extensively, although as they got larger (and stream flows reduced), they sought areas that were deeper and higher velocity (Hillman et al. 1989 CPa). Substrate preference also changed as the juvenile chinook got larger and hydraulic conditions changed from predominantly sand, large boulder, and bedrock to sand, sand-gravel, and cobble. As temperatures dropped below 10 °C, salmon were observed primarily near boulder rip-rap, or concealed themselves in the substrate.

During nighttime hours during the warmer months, chinook moved inshore and rested all night in shallow, quiet water (Hillman et al. 1989 CPb). In the colder months, chinook sought deeper water with larger substrate. Entiat River spring chinook most likely use similar habitats as those in the Entiat River.

Conservation of high functioning habitat in the Entiat and Mad rivers, restoration of riparian and geofluvial processes in or near known and potential parr rearing areas will have the highest likelihood of increasing parr survival.

Smolt

Entiat River spring chinook smolts begin migrating in March from natal areas. Investigation of suspected or potential impediments to migration or injury or mortality should be identified and investigated. If areas are shown to unnaturally impede migration or injure or kill fish, then they should be fixed.

Population Characterization

Distribution

Historic

Mullan (1987) felt that because of the geology of the region upstream of the current Grand Coulee Dam site, that that spring chinook were not very abundant, with the possible exceptions of the San Poil and Spokane River basins. Fulton (1968) described the historic distribution of spring chinook in the Entiat River. He relied heavily on the fieldwork of French and Wahle (1965) for his information on distribution. Fulton (1968) includes most of the mainstem Entiat as habitat for spring and summer chinook, noting that steep gradients of tributaries prevent salmon use.

Current

Hamstreet and Carie (2003) describe the current spawning distribution for spring chinook as between river miles 16 and 28 in the Entiat River and 1.5 to 5 in the Mad River, its major tributary. Also see Figure 8.

Subwatersheds Significant for Spring Chinook in Wenatchee and Entiat Subbasins

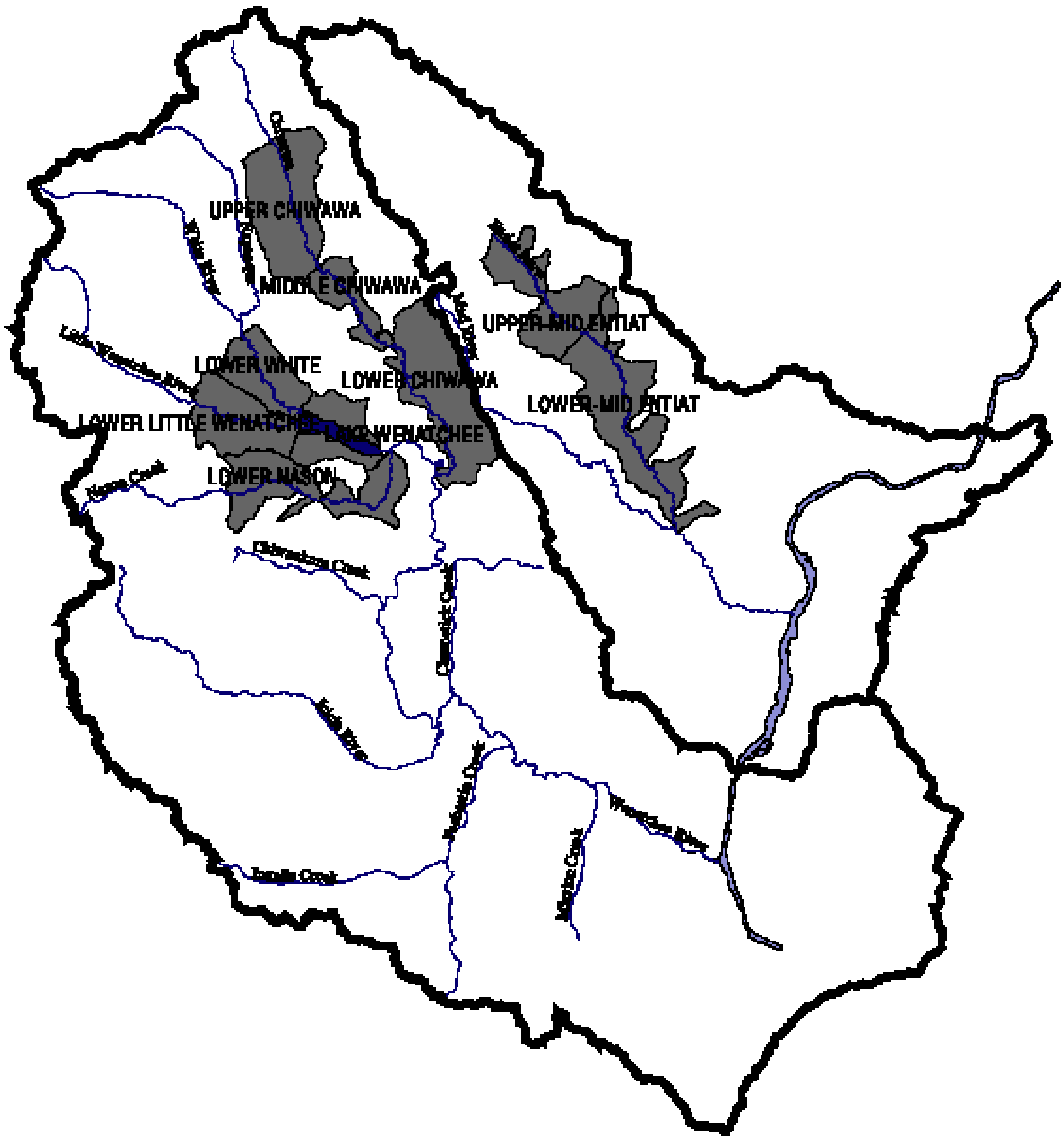


Figure 8. Significant spring chinook watersheds in Wenatchee and Entiat subbasins (RTT 2004)

Abundance

Historic

Chapman (1986) stated that large runs of chinook and sockeye, and lesser runs of coho, steelhead and chum historically returned to the Columbia River. Based on the peak commercial catch of fish in the lower Columbia River and other factors, such as habitat capacity, he estimated that approximately 588,000-spring chinook was the best estimate of pre-development run sizes. Spring chinook were relatively abundant in upper Columbia River tributary streams prior to the extensive resource exploitation in the

1860s. By the 1880s, the expanding salmon canning industry and the rapid growth of the commercial fisheries in the lower Columbia River had heavily depleted the mid and upper Columbia River spring and summer chinook runs (McDonald 1895), and eventually steelhead, sockeye and coho (Mullan 1984, 1986, 1987; Mullan et al. 1992). The full extent of depletion in upper Columbia River salmonid runs is difficult to quantify because of limited historical records, but the runs had been decimated by the 1930s (Craig and Suomela 1941). Many factors including construction of impassable mill and power dams, un-screened irrigation intakes, poor logging and mining practices, overgrazing (Fish and Hanavan 1948; Bryant and Parkhurst 1950; Chapman et al. 1982), and private development of the subbasins, in combination with intensive fishing, all contributed to the decline in abundance of Upper Columbia basin salmonids.

Spring chinook counting at Rock Island Dam began in 1935. Numbers (adults and jacks) in the period 1935-39 averaged just over 2,000 fish. Average counts fluctuated on a decadal average from the 1940s to 1990s from just over 3,200 (1940s) to over 14,400 (1980s), with recent counts (2000-2002) averaging almost 29,000. The long-term average of spring chinook passing Rock Island Dam is just over 8,900.

Current

Redd counts in the Entiat River basin have been conducted since 1962. Decadal averages are 205, 143, 89, 33, and 81 between 1962 and 2002, with a long term average over the spanning years of 110.

For the Entiat River, Ford et al. (2001) recommended an interim recovery level of 500 spawners per year. The historic redd counts suggest an escapement ranging from 2 to 845, and has averaged 215 since 1962.

Productivity

Historic

Historic production of spring chinook is difficult to determine, although it was most likely not as high as sockeye or late-run chinook. While it is known that in some years, there was drastic failure of certain year classes (primarily due to ocean conditions; see Mullan 1987; Mullan et al. 1992), it is assumed that historic production of salmon was high, especially for summer/fall chinook and sockeye.

Current

Current productivity is affected by loss, or degradation of habitat in spawning and rearing areas, increased downstream mortality through the mainstem Columbia River, ocean conditions, and other abiotic factors (drought, etc.). Mullan et al. (1992) postulated that current production may not be greatly different than historic for spring chinook. Caveats to this postulate are that native coho are extinct, production comes at a higher cost in terms of smolt survival through the mainstem corridor, and that harvest is drastically reduced (e.g., over 80% in the lower Columbia River in the late 1930s, early 1940s). However, recent estimates of natural replacement rates for spring chinook suggest that they are not replacing themselves in most years until the broods of the late 1990s (A. Murdoch, personal communication).

There are still habitat areas in need of restoration within the Entiat Basin. By increasing known areas in need of restoration, it is reasonable to assume that production of spring chinook would increase.

Diversity

Because some areas within the Entiat Basin are in need of habitat improvements, diversity within the basin is believed to be lower than historic. While the Entiat population is still believed to be an *independent population* (see definition in Appendix _), increased habitat would most likely increase spatial and life history diversity.

Table 16. Summary of spring chinook presence in the Entiat subbasin

	Distribution	**Abundance**	**Productivity**	**Diversity**
Historic	High	Moderate	Moderate	Moderate
Current	Mod-high	Low-mod.	Low-mod.	Low-mod.

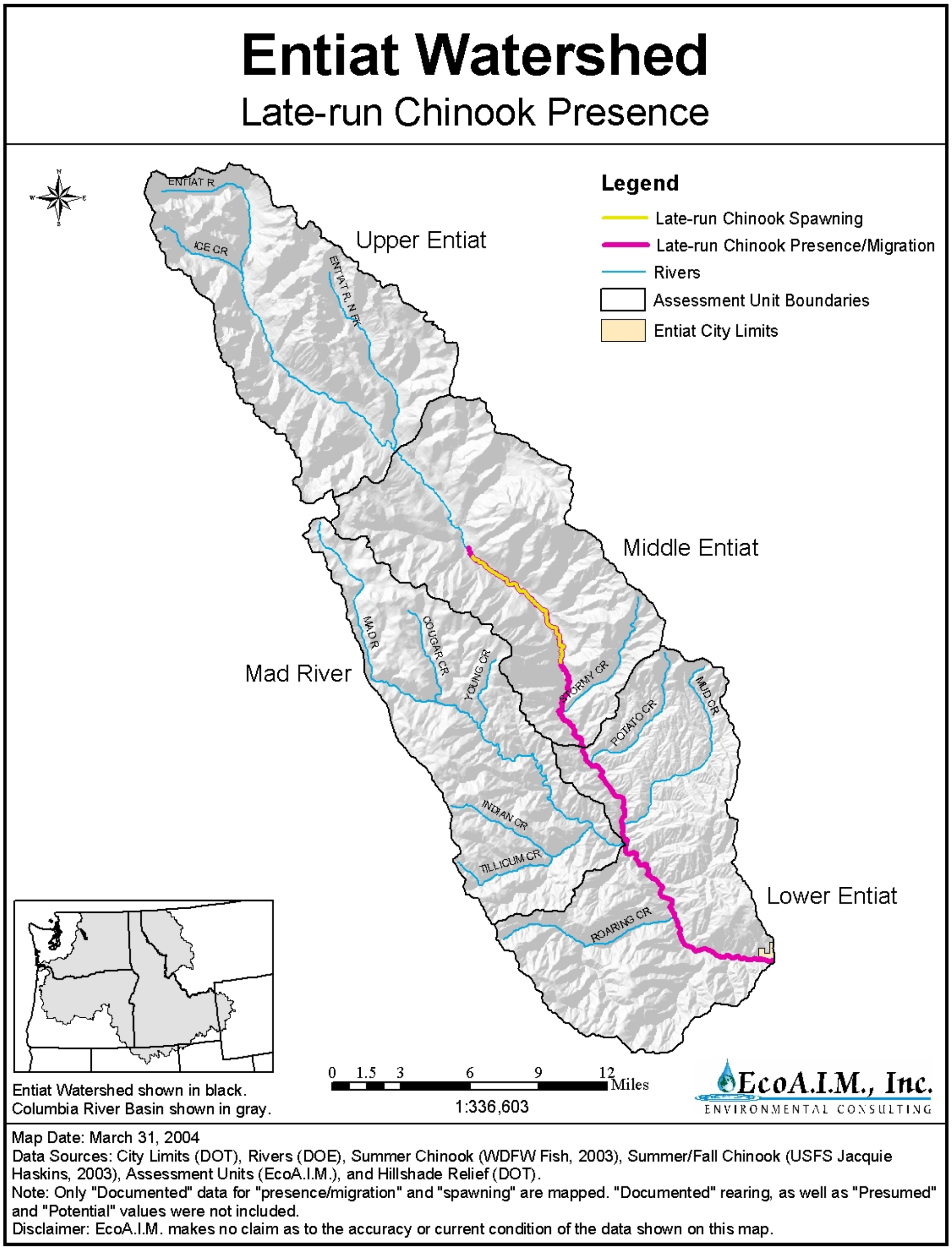


Figure 9. Late-run chinook distribution in the Entiat subbasin

4.8.3 Late-run Chinook Salmon (*Oncorhynchus tshawytscha*)

Rationale for Selection

Virtually all late-run Chinook salmon returning to the Entiat River spawn in 23 miles of the mainstem downstream of Preston Creek confluence. It is suspected that late-run Chinook salmon were not a dominant life history type in the Entiat River system (Craig and Suomela 1941); however, a great effort was made to establish late-run Chinook in the Entiat after the GCFMP. Intensive spawning survey monitoring of these fish has been ongoing since 1994. Because of the heavy reliance of late-run Chinook to the lower Entiat River, these fish are a good indicator of ecosystem health.

Key Life History Strategies, Relationship to Habitat

Time of entry and spawning

Adult summer/fall chinook begin entering the Entiat River basin in June. Spawning begins in very late September through mid November, peaking in mid- to late October. The onset of spawning in a stream reach is temperature driven (usually when temperatures drop below 16 °C). Temperatures in the mainstem Entiat are influenced by climate and tributary flows.

Prespawning

Adults hold in the deeper pools and under cover of the mainstem Entiat. The availability of and number of deep pools and cover is important to offset potential prespawning mortality. Intact riparian habitat will increase the likelihood of instream cover, and normative channel geofluvial processes will increase or maintain the occurrence of deeper pools.

Redd characteristics

Important habitat needs for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. Healy (1991) reports the range of depths of spawning as between 41 to > 700 cm (~1-23 ft) and velocities of between 10 to 150 cm/s (.33-5 ft/s) for chinook salmon (this includes spring-type chinook too). Preservation or restoration of naturally occurring geofluvial function insures that the proper spawning habitat is available.

Incubation and emergence

Healy (1991) reports that incubation and emergence success was related to oxygen levels and percolation through the gravel. When percolation was 0.03 cm/s (0.001 ft/s), survival to hatching was 97%. However, emergence reduced to 13% when percolation was 0.06 cm/s (0.002 ft/s). When oxygen fell below 13 ppm, mortality of eggs increased from 3.9% at 13 ppm to about 38% at 5 ppm.

Stream conditions (e.g., frequency of flooding, extreme low temperatures) may affect egg survival too. Floods can scour eggs from the gravel by increasing bedload movement. High flows associated with unstable stream banks increases sediment deposition that reduces oxygen and percolation through the redd. Healy (1991) cites Shaw and Maga (1943) as showing that siltation may be more lethal earlier in the incubation period than in later phases. Overall, Healy (1991) reports that spawning to emergence ranged from 40-100% (these estimates include spring-type chinook too).

In the Entiat Basin, fall flooding has a high frequency of occurrence. This may negatively affect incubation and emergence success, especially in years of extreme flows (e.g., 1990 and 1995). Road building activities in the upper watersheds may also increase siltation, as well as grazing and mining activities. All three factors were once more prevalent than they are now in the basin, and conditions have improved in most watersheds. Because of naturally occurring conditions and major events like fire, tributary creeks have had heavy sediment load events in the last 10-15 years.

Fry

Fry emerge mostly in April and May. Most subyearling summer/fall chinook leave the probably leave the Entiat River within a few weeks after emergence, as has been observed within the Entiat River. In the Entiat River, Hillman and Chapman (1989) demonstrated that the rate of emigration of subyearling chinook was highest in June, then declined through the summer.

Summer/fall chinook fry utilize near-shore areas, primarily eddies, within and behind large woody debris, undercut tree roots, or other cover (Hillman et al. 1989a; Healy 1991). They noted that in the spring this type of habitat was scarce in the Entiat River, but where it did occur, it was fully occupied. Conservation and restoration of riparian areas and increases in off-channel habitat in the lower Entiat Basin may increase the type of habitat that summer/fall chinook fry utilize, although they may still emigrate through the system without utilizing these habitats.

Population Characterization

Distribution

Historic

Summer/fall chinook did not historically spawn in the Entiat River (Craig and Suomela 1941; Mullan 1987).

Current

Spawning of summer/fall chinook salmon in the Entiat River is a result of the Entiat National Fish Hatchery, which released chinook into the river between 1941 and 1976 (Mullan 1987). While late-run chinook may never have spawned naturally in the Entiat River, there does appear to be a self-sustaining population present currently. (Also see Figure 10.) This population is small in relation to the Entiat or Similkameen River basins.

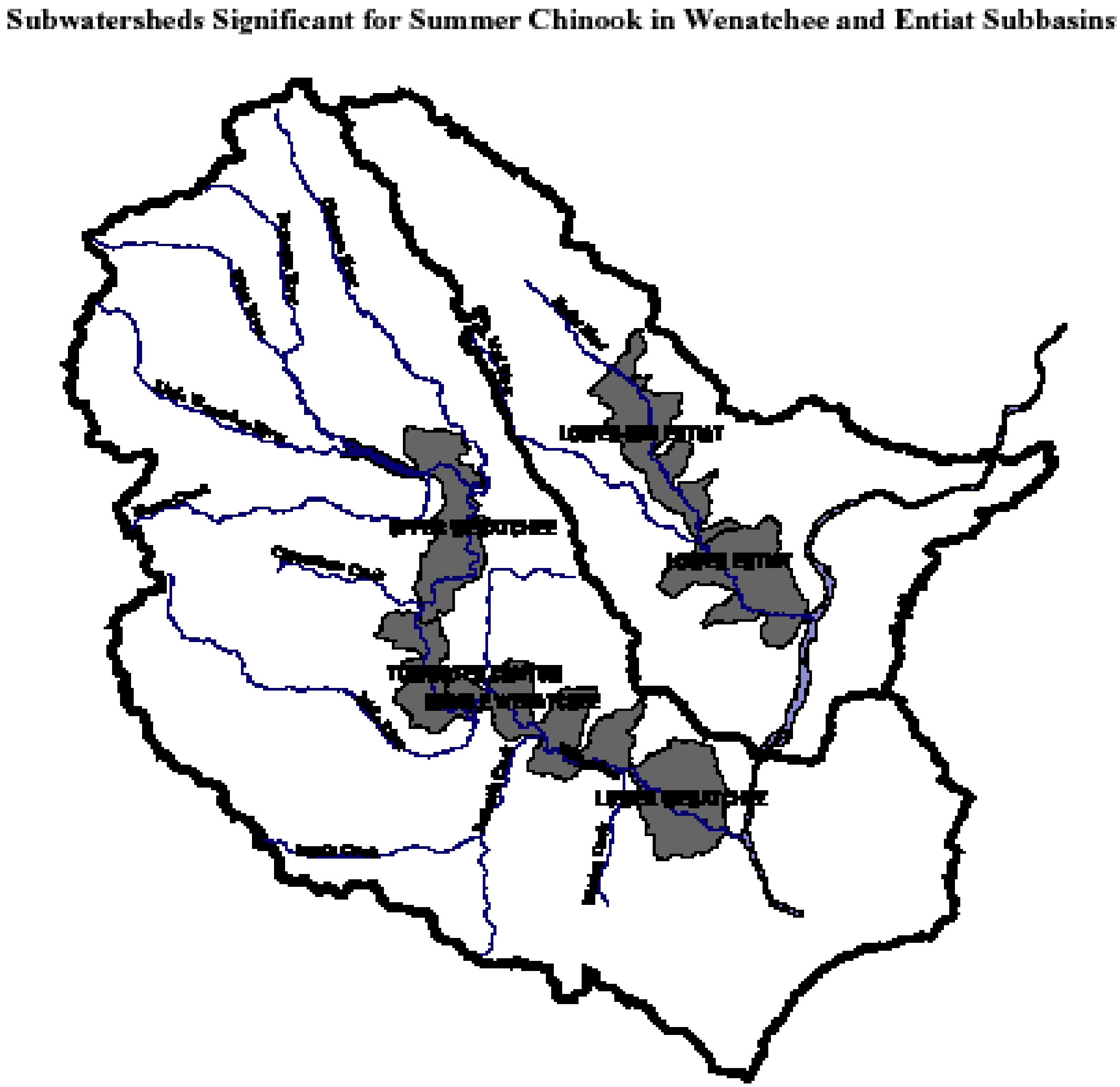


Figure 10. Significant late-run chinook watersheds in the Wenatchee and Entiat subbasins (RTT 2004)

Abundance

Historic

Chapman (1986) stated that large runs of chinook and sockeye, and lesser runs of coho, steelhead and chum historically returned to the Columbia River. Based on the peak commercial catch of fish in the lower Columbia River and other factors, such as habitat capacity, he estimated that approximately 3.7 million summer chinook, (for the entire

Columbia Basin) was the best estimate of pre-development run sizes. Summer/fall chinook were very abundant in upper Columbia River and tributary streams prior to the extensive resource exploitation in the 1860s. By the 1880s, the expanding salmon canning industry and the rapid growth of the commercial fisheries in the lower Columbia River had heavily depleted the mid and upper Columbia River spring and summer chinook runs (McDonald 1895), and eventually steelhead, sockeye and coho (Mullan 1984, 1986, 1987; Mullan et al. 1992). The full extent of depletion in upper Columbia River salmonid runs is difficult to quantify because of limited historical records, but the runs had been decimated by the 1930s (Craig and Suomela 1941). Many factors including construction of impassable mill and power dams, un-screened irrigation intakes, poor logging and mining practices, overgrazing (Fish and Hanavan 1948; Bryant and Parkhurst 1950; Chapman et al. 1982), and private development of the subbasins, in combination with intensive fishing, all contributed to the decline in abundance of Upper Columbia basin salmonids.

Historically, the late spring and summer components of the Columbia River chinook populations were the most abundant and heavily fished (Thompson 1951, Van Hyning 1968, Chapman 1986). Overfishing in the lower Columbia River rapidly depressed summer-run chinook. Spawning and rearing habitat extirpation and destruction accelerated the decline.

Decadal averages of summer/fall chinook escapements at Rock Island Dam from 1933 through 2002 show a rising trend. Harvest rates in the 1930s and 1940s were very high in the lower river fisheries, and no doubt had a large impact on the escapement at Rock Island (Mullan 1987). In 1951, when harvest rates in zones 1-6 (lower Columbia River) were reduced, numbers increased dramatically. Between the 1930s (starting in 1933) and 1960s (excluding 1968 and 1969) (Unfortunately, there were no counts at Rock Island Dam between 1968 and 1972.), total (adults and jacks) decadal average numbers of summer/fall chinook rose from just over 7,000 to almost 28,000. Numbers remained high in the 1970s until the mid-1980s, when they declined through the 1990s and have shown a sharp increase in the 2000s.

In the 1960s, dam counts became available at Rocky Reach Dam (1962) and Wells Dam (1967). These project counts of total summer/fall chinook show a different trend than Rock Island, which suggests the difference being the fish that spawn in the Entiat River were heavily affecting the trend at Rock Island Dam.

Current

Redd counts have been conducted in the Entiat River since 1957. Counts ranged from 0-55 between 1957 and 1991 (Peven 1992). Between 1994 and 2002, Hamstreet and Carie (2003) estimated the number of summer/fall chinook redds ranging between 15-218, averaging 75.

Productivity

Historic

Historic productivity of late-run chinook in the Entiat was non-existent.

Current

Current productivity is affected by loss, or degradation of habitat in spawning and rearing areas, increased downstream mortality through the mainstem Columbia River, ocean conditions, and other abiotic factors (drought, etc.).

Spawning habitat may be limiting for summer/fall chinook in the Entiat Basin, but, other factors, such as the potential changes to geo-fluvial processes may affect immediate rearing (or refuge) areas in the lower river more. It is unknown what affect this has on production.

Diversity

Because some areas within the Entiat Basin are in need of habitat improvements, diversity within the basin may be lower than historic. Increased habitat would most likely increase life history diversity.

Currently, genetic sampling has not found any differences among late-run chinook within the basin.

Table 17. Summary of late-run chinook presence in the Entiat subbasin

	Distribution	Abundance	Productivity	Diversity
Historic	Very Low	Very Low	Very Low	Very Low
Current	Moderate	Low	low	low

4.8.4 Coho (*Oncorhynchus kisutch*)

Rationale for Selection

Coho salmon were once considered extinct in the mid Columbia region, but have since been reintroduced to the Wenatchee and Methow sub-basins. Mullan (1984) estimated the historical run size at 38,000 to 51,000 adults to the Wenatchee, Entiat, and Methow rivers (Peven 2003). The Yakama Nation's substantial and concerted effort to reintroduce coho into the upper Columbia, using the Wenatchee and Methow sub basins during the feasibility phase of this work will be expanded to included the Entiat sub-basin after 2005.

Coho salmon prefer and occupy different habitat types, selecting slower velocities and greater depths than the other focal species; Habitat complexity and off-channel habitats such as backwater pools, beaver ponds, and side channels are important for juvenile rearing making coho good biological indicators for these areas.

Key Life History Strategies: Relationship to Habitat

Time of entry and spawning

Coho salmon enter the Wenatchee River in early September through late November. It is likely that coho timing to enter the Entiat River would be similar. Adults ascended the tributaries in the fall and spawning between mid-October and late December, although there is historical evidence of an earlier run of coho salmon (Mullan 1984). As cold water temperatures at that time of year preclude spawning in some areas, it is likely that coho salmon spawn in areas where warmer ground water up-wells through the substrate.

Prespawning

Coho entering in September and October hold in larger pools prior to spawning, later entering fish may migrate quickly upstream to suitable spawning locations. The availability and number of deep pools and cover is important to off set potential prespawning mortality. Intact riparian habitat will increase the likelihood of in stream cover, and normative channel geofluvial processes will increase the occurrence of deeper pools.

Redd characteristics

Important habitat need for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. Burner (1951) reported the range of depths for coho spawning to be between 8 and 51 cm. Coho salmon spawn in velocities ranging from 0.30 to 0.75 m/s and may seek out sites of groundwater seepage (Sandercock 1991).

Incubation and emergence

The length of time required for eggs to incubate in the gravel is largely dependent on temperature. Sandercock (1991) reported that the total heat requirement for coho incubation in the gravel (spawning to emergence) was 1036 (±138) degree (°C) days over zero. The percentage of eggs and alevins that survive to emergence depends on stream and streambed conditions. Fall and winter flooding, low flows, freezing of gravel, and heavy silt loads can significantly reduce survival.

Fall and winter flooding may negatively affect incubation and emergence success, especially in years of extreme flow. Road building activities in the upper watersheds may also increase siltation, as well as grazing and mining activities. All three factors were once more prevalent than they are now in the basin, and the conditions have improved in most watersheds.

In the Wenatchee sub-basin, coho fry emerge from the gravel in April or May (K. Murdoch, personal communication). It is likely that coho in the Entiat Basin will have similar emergence timing.

Fry

Juvenile coho salmon generally distribute themselves downstream shortly after emergence and seek out suitable low gradient tributary and off channel habitats. They congregate in quiet backwaters, side channels, and shady small creeks with overhanging vegetation (Sandercock 1991). Conservation and restoration of riparian areas, and off channel habitat in natal streams within the Entiat Basin would increase the type of habitat fry use.

Parr

Coho salmon prefer slower velocity rearing areas than chinook salmon or steelhead (Lister and Genoe 1970; Allee 1981; Taylor 1991) Recent work completed by the Yakama Nation supports these findings (Murdoch et. al. 2004). Juvenile coho tend to overwinter in riverine ponds and other off channel habitats. Overwinter survival is strongly correlated to the quantity of woody debris and habitat complexity (Quinn and Peterson 1996). Conservation of and restoration of high functioning habitat in natal tributaries along and restoration of riparian and geofluvial processes in or near known and potential parr rearing areas will have the highest likelihood of increasing parr survival.

Smolt

Naturally produced coho smolts in the Wenatchee Basin emigrate between March and May (Murdoch et. al. 1994). Emigration timing for coho in the Entiat River will likely be the same. Investigation of suspected or potential impediments to migration or injury or mortality should be identified and investigated. If areas are shown to unnaturally impede migration or injure or kill fish, they should be fixed.

Population Characterization

Distribution

Historic

Coho salmon were once considered extirpated in the upper Columbia River (Fish and Hanavan 1948; Mullan 1984), but have since been reintroduced. Mullan (1984) estimated that upstream of the Yakima River, the Methow River and Spokane River historically produced the most coho, with lesser runs into the Wenatchee and Entiat. The historic run of coho in the Entiat River was estimated to be 9000-13000 adults annually (Mullan 1984). There are conflicting reports of whether the Okanogan subbasin historically produced coho (Craig and Suomela 1941; Vedan 2002). Because the historic stock of coho salmon no longer occur in the upper Columbia River system, the Entiat subbasin coho are not addressed under the ESA or by the WDFW (1994) SASSI (Peven 2003).

Information regarding the historic distribution of coho salmon within the Entiat River basin is limited, but similar to the Wenatchee River, they will likely spawned in lower and mid-elevation tributaries and the main-stem.

Current

Currently, coho have not been reintroduced to the Enitat River, although limited natural production in the Enitat has occurred as a direct result of the coho reintroduction efforts in the Wenatchee and Methow sub-basins. The Yakama Nation is developing a plan to release coho in the Entiat basin in 2005.

Abundance

Historic

Historically 120,000-166,500 coho were attributed to the mid-and upper Columbia tributaries (Yakima, Wenatchee, Entiat, Methow, and Spokane Rivers: Mullan 1984). Mullan (1984) estimated that the Entiat River supported adult returns of approximately 9,000-13,000 coho.

There were two previous attempts in the twentieth century to rebuild coho populations though these two programs were not designed or intended to rebuild upriver runs. They were for harvest augmentation. Releases did not occur in the natural production habitat areas within the watershed.. Between the early 1940s and the mid 1970s, the USFWS raised and released coho as part of their mitigation responsibilities for the construction of Grand Coulee Dam (Mullan 1984). Chelan PUD also had a coho hatchery program until the early 1990s. While some natural production may have occurred from these releases, the programs overall were not designed to re-establish naturally spawning populations, and relied on lower river stocks that were not suited to the upper Columbia (Peven 2003). All coho releases under the Chelan PUD program (197-1993) were made from the Turtle Rock Fish Hatchery, located in the middle of the Columbia River above Rocky Reach Dam. The release location likely contributed to the inability to produce a naturally spawning coho run. This reach of the Columbia River does not provide suitable coho spawning and rearing habitat.

Current

The Yakama Nation, as the lead agency, has implemented a substantial reintroduction program designed to restore naturally reproducing coho salmon through the development a locally adapted stock, while releasing acclimated smolts in natural production areas. The reintroduction effort in the Wenatchee has resulted in the ongoing development of a locally adapted broodstock, which would be used to reintroduce coho to the Entiat sub-basin and natural production. The first generation of naturally produced coho smolts emigrated from the Wenatchee River basin in 2002 with an estimated population size of

17,000 (Murdoch et al. 2004). In 2003, approximately 36,700 naturally produced coho smolts emigrated from the Wenatchee River (T. Miller, WDFW, unpublished data).

The reintroduction of coho salmon to the Entiat sub-basin will substantially increase the abundance of coho in mid-Columbia region.

Productivity

Historic

Historic production of coho salmon is difficult to determine, although it was most likely not as high as or late-run chinook.

Current

Current coho productivity is affected by loss, or degradation of habitat in spawning and rearing areas, increased downstream mortality through the mainstem Columbia River, ocean conditions, and other abiotic factors (drought, etc). There are still habitat areas in need of restoration within the Entiat Basin. By increasing known areas in need of restoration, it is reasonable to assume that production of reintroduced coho would increase.

Diversity

Because hatchery stocks were used to reintroduced coho salmon (and develop a local broodstock) to mid-Columbia tributaries, spatial and life history diversity within the Entiat basin will initially be lower than the historic populations of coho salmon. However, coho reintroduction in Entiat basin will increase the diversity of the locally adapting stock in mid-Columbia tributaries. As increased natural production occurs diversity will likely increase. Increased habitat will most likely increase spatial and life history diversity for coho salmon in mid-Columbia tributaries.

Table xx. Summary of coho salmon population characterization.

	Distribution	**Abundance**	**Productivity**	**Diversity**
Historic	High	Mod-high	Moderate	High
Current	Low	Low	Low	Low

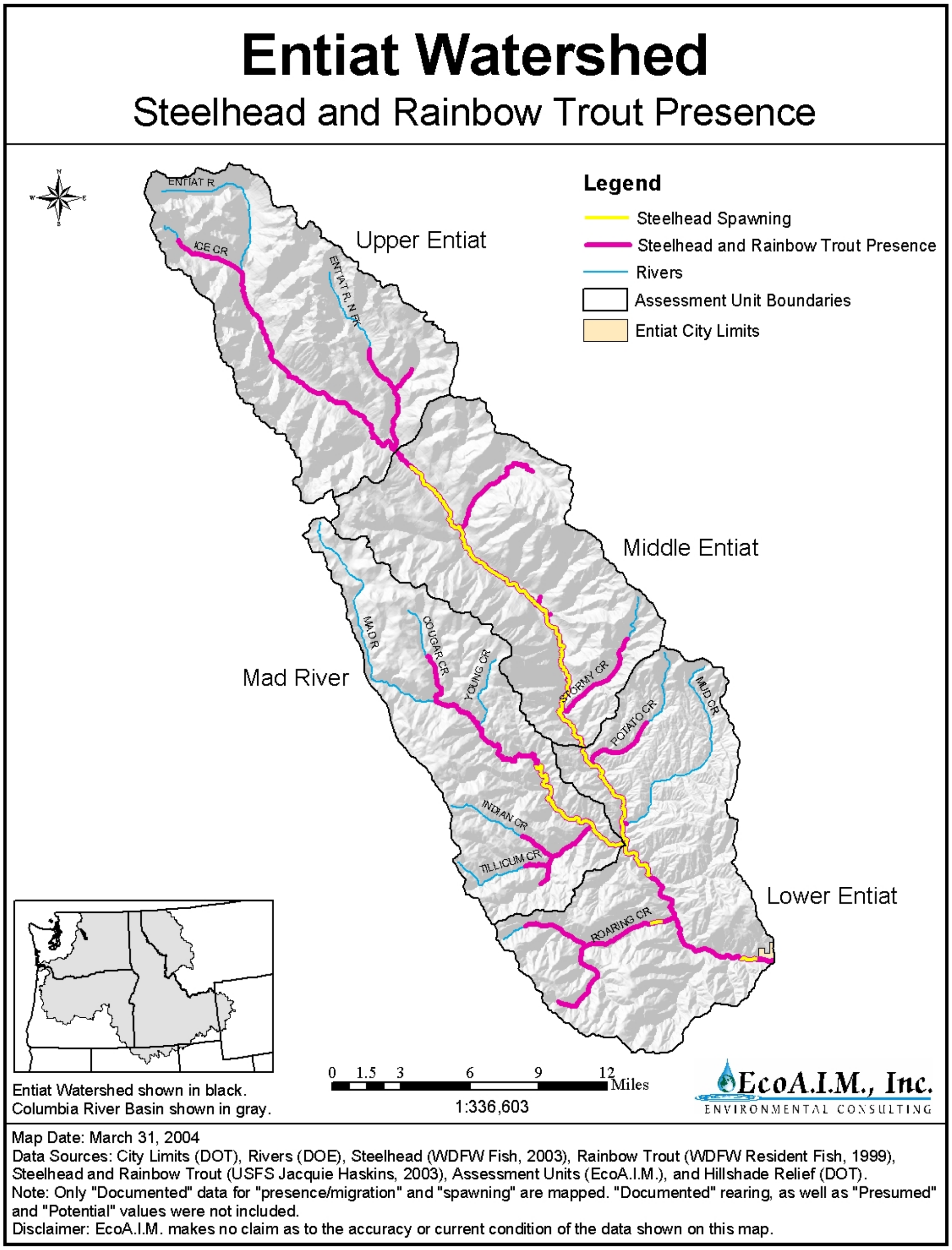


Figure 11. Steelhead trout distribution in the Entiat subbasin

4.8.5 Steelhead Trout (*Oncorhynchus mykiss*)

Rationale for Selection

The Entiat steelhead is included by NOAA Fisheries into the Upper Columbia ESU and is listed as an endangered under the ESA. Steelhead trout use all of the major tributaries of the Entiat subbasin except the upper Entiat due to existing barrier to passage (Figure 17). Steelhead juvenile spend two or more years in the Entiat mainstem and tributaries using many different habitat types making them a good biological indicator of ecosystem health.

Key Life History Strategies, Relationship to Habitat

Time of entry and spawning

Adult steelhead enter the Entiat River basin from August through the following April. Spawning begins in very late March through April, potentially going into May, peaking in mid- to late April in the Mad River (Archibald 2003). The onset of spawning in a stream reach is temperature driven. Other factors may influence steelhead spawning compared to salmon species because of the time of year spawning occurs.

Prespawning

Adults hold in the deeper pools and under cover of the mainstem Entiat River or natal tributaries. The availability of and number of deep pools and cover is important to offset potential prespawning mortality. Intact riparian habitat will increase the likelihood of instream cover, and normative channel geofluvial processes will increase the occurrence of deeper pools.

Redd characteristics

Important habitat needs for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. Wydoski and Whitney (2003) report that spawning is usually found at a mean depth of 0.7 to 1.34 ft and water velocities of 1.8 to 2.3 fps. Preservation or restoration of naturally occurring geofluvial function insures that the proper spawning habitat is available.

Incubation and emergence

Incubation success is dependent on factors such as water flow through the redds and temperature (Pauley et al. 1996). Eggs usually hatch in 4 to 7 weeks and fry emerge 2 to 3 weeks after that (Shapovalov and Taft 1954).

Stream conditions (e.g., frequency of flooding, extreme low temperatures) may affect egg survival too. Floods can scour eggs from the gravel by increasing bedload movement. High flows associated with unstable stream banks increases sediment deposition that reduces oxygen and percolation through the redd. Healy (1991) cites Shaw and Maga (1943) as showing that siltation may be more lethal earlier in the incubation period than in later phases.

In the Entiat Basin, fall flooding has a high frequency of occurrence. This may negatively affect incubation and emergence success, especially in years of extreme flows (e.g., 1990 and 1995). Road building activities in the upper watersheds may also increase siltation, as well as grazing and mining activities. All three factors were once more prevalent than they are now in the basin, and conditions have improved in most watersheds.

Fry

In the Entiat River, Hillman and Chapman (1989) found most juvenile steelhead rearing in Tumwater Canyon. During daylight, age-0 steelhead used slower, shallower water than chinook, stationed individually over small boulder and cobble substrate (Hillman et al. 1989 CPa). As they grew, they picked deeper and faster habitat over cobble and boulders. As with chinook juveniles, in winter, they concealed themselves in interstitial spaces among boulders near the stream bank, but did not cluster together. No interaction was observed between chinook and steelhead at anytime (Hillman et al. CPa, CPb).

During nighttime hours, steelhead moved downstream and closer to shore. At dawn, steelhead moved upstream. Most steelhead chose sand and boulder substrates, and during winter, chose deeper, larger substrate (Hillman et al. 1989 CPb).

Hillman and Miller (2002) remarked that in ten years of surveying the Chiwawa River, age-0 steelhead most often used riffle and multiple channel habitats, but were also found associated with debris in poll and glide habitat.

It is reasonable to assume that Entiat Basin steelhead utilize similar habitats as those in the Entiat Basin.

Conservation and restoration of natural geofluvial processes and riparian areas of natal streams within the Entiat Basin would increase the type of habitat that fry utilize.

Parr

Downstream movement of parr from natal streams occurs within the Entiat Basin (Murdoch et al. 2001). French and Wahle (1959) found that juvenile steelhead migrated past Tumwater Dam on the Entiat River (RM 33) from spring through late fall. Since 1992, sampling by WDFW has found steelhead emigrating from the Chiwawa River as pre-smolts beginning in spring, but primarily in the fall. In general, movement from the Chiwawa River included some yearlings leaving as early as March, extending through May, followed by subyearlings leaving through the summer and fall (until trapping ceases because of inclement weather; A. Murdoch, WDFW, personal communication). Similar timing of movement probably occurs in the Entiat Basin.

Movement of juvenile steelhead from the higher-order streams in the fall appears to be a response to the harsh conditions encountered in the upper tributaries. Hillman and Chapman (1989) suggested that biotic factors, such as intraspecific interaction for available habitat with naturally- and hatchery- produced chinook, nocturnal sculpin predation, and interspecific interactions may accelerate movement of chinook and steelhead juveniles from the mainstem Entiat River. It is reasonable to assume that similar behavior is seen in Entiat River steelhead.

Mullan et al. (1992) found that most steelhead reared in the lower portions of the Entiat and Mad rivers. The amount of habitat diversity and complexity in these reaches compared to other reaches was believed to be responsible for this behavior.

Conservation of high functioning habitat in natal tributaries and the Mad and Entiat rivers, restoration of riparian and geofluvial processes in or near known and potential parr rearing areas will have the highest likelihood of increasing parr survival.

Smolt

Entiat River steelhead smolts begin migrating in March from natal areas. Investigation of suspected or potential impediments to migration or injury or mortality should be identified and investigated. If areas are shown to unnaturally impede migration or injure or kill fish, then they should be fixed.

Population Characterization

Distribution

Historic

Steelhead historically used all major (and some minor) tributaries within the Upper Columbia Basin for spawning and rearing (Chapman et al. 1994). Fulton noted the mainstem Entiat and Mad Rivers as producing steelhead.

Current

Current distribution in the Entiat is believed to be similar to historic, although some minor tributaries may not encourage certain life history phases because of habitat degradation from natural and human-caused reasons. (See Figure .

Abundance

Historic

Chapman (1986) stated that large runs of chinook and sockeye, and lesser runs of coho, steelhead and chum historically returned to the Columbia River. Based on the peak commercial catch of fish in the lower Columbia River and other factors, such as habitat capacity, he estimated that approximately 554,000 steelhead (for the entire Columbia Basin) was the best estimate of pre-development run sizes. Steelhead were relatively abundant in upper Columbia River tributary streams prior to the extensive resource exploitation in the 1860s. By the 1880s, the expanding salmon canning industry and the rapid growth of the commercial fisheries in the lower Columbia River had heavily depleted the mid and upper Columbia River spring and summer chinook runs (McDonald 1895), and eventually steelhead, sockeye and coho (Mullan 1984, 1986, 1987; Mullan et al. 1992). The full extent of depletion in upper Columbia River salmonid runs is difficult to quantify because of limited historical records, but the runs had been decimated by the 1930s (Craig and Suomela 1941). Many factors including construction of impassable mill and power dams, un-screened irrigation intakes, poor logging and mining practices, overgrazing (Fish and Hanavan 1948; Bryant and Parkhurst 1950; Chapman et al. 1982), and private development of the subbasins, in combination with intensive fishing, all contributed to the decline in abundance of Upper Columbia basin salmonids.

Steelhead counts began at Rock Island Dam in 1933, and annual counts averaged 2,800 between 1933 and 1939 (these numbers do not reflect large fisheries in the lower river that took place at that time, estimated by Mullan et al. (1992) as greater than 60%).

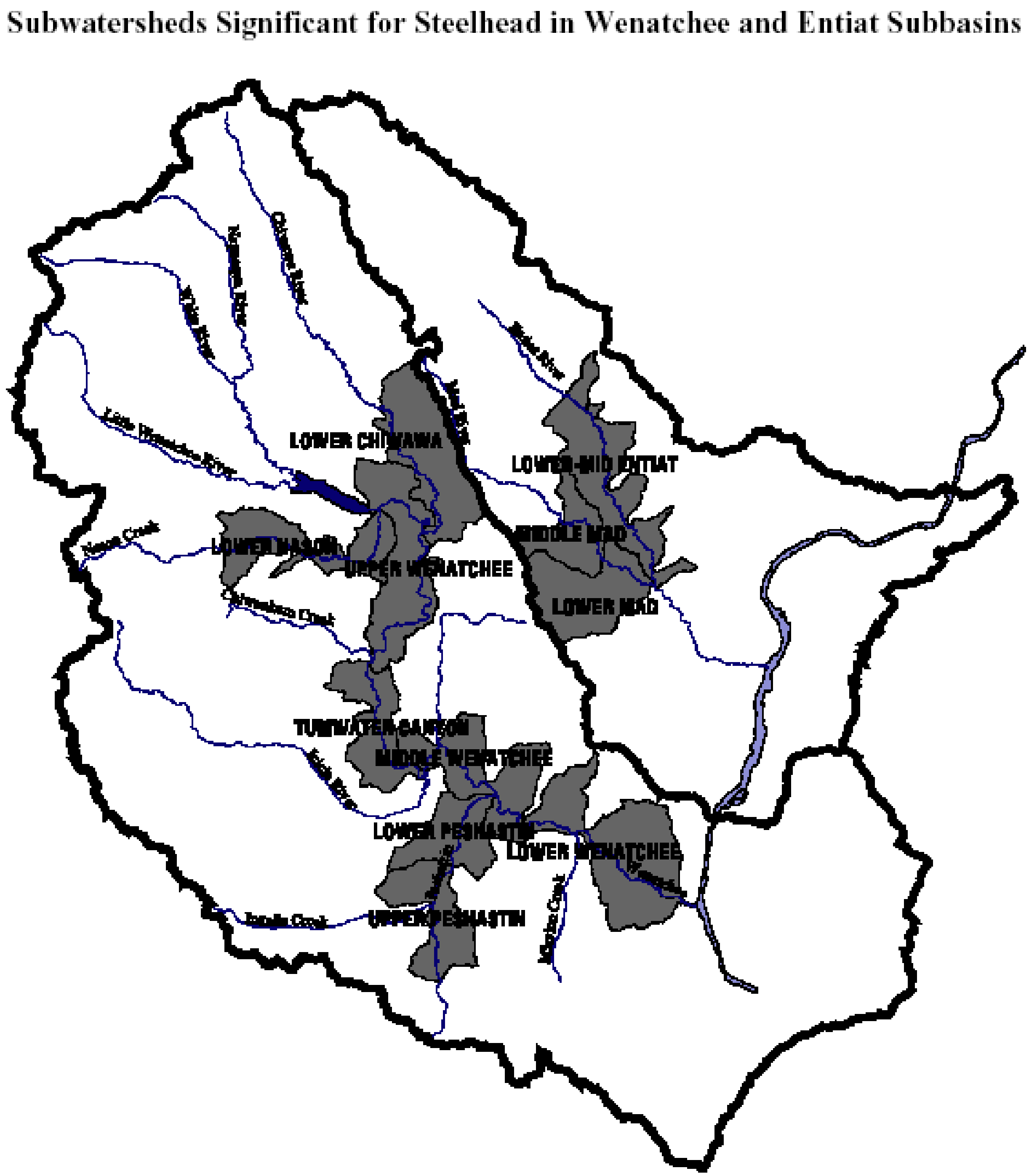


Figure 12. Significant steelhead watersheds in the Wenatchee and Entiat subbasins (RTT 2004)

Average decadal numbers changed little in the 1940s and 1950s (2,600 and 3,700, respectively). Large hatchery releases began in the 1960s, and the average counts increased to 6,700. In the 1970s, counts averaged 5,700 and 16,500 in 1980s (record count of about 32,000 in 1985). In the 1990s, counts decreased, following a similar trend as chinook, to 7,100, while, similar to chinook, they have increased substantially so far in the 2000s, with an average of over 18,000 (a high of 28,600 in 2001).

Current

Beginning in 1997 (no survey was conducted in 1998), the USFS has been conducting limited spawning ground surveys for *O. mykiss* in the Mad River (Archibald 2003). The area covered has increased from the first 3 miles of the Mad River to up to 10 miles (currently the first 7 miles) of the Mad River. Roaring Creek has been surveyed too, but apparently not the mainstem Entiat River. The number of "definite" redds has ranged from 0 (1999) to 38 (2003), averaging 13. Beginning in 2003, the FWS began conducting steelhead spawning surveys on the mainstem Entiat River from approximately RM 2 through28. Eighty redds were found during the first year of the survey (K.Terrell, personnal communication to C.Peven May, 2004)

Ford et al. (2001) recommended interim recovery levels of about 500 naturally produced spawners for the Entiat, using similar criteria that were used for spring chinook.

Productivity

Historic

Historic production of steelhead is difficult to determine, although it was most likely not as high as sockeye or late-run chinook. While it is known that in some years, there was drastic failure of certain year classes (primarily due to ocean conditions; see Mullan et al. 1992); it is assumed that historic production of steelhead was higher than current.

Current

Current productivity is affected by loss, or degradation of habitat in spawning and rearing areas, increased downstream mortality through the mainstem Columbia River, ocean conditions, and other abiotic factors (drought, etc.).

Mullan et al. (1992) postulated that current production may not be greatly different than historic for steelhead. Caveats to this postulate are that native coho are extinct, production comes at a higher cost in terms of smolt survival through the mainstem corridor, and that harvest is drastically reduced. However, recent estimates of natural replacement rates for steelhead suggest that they are not replacing themselves in most years until the broods of the late 1990s (Peven 2003).

There are still habitat areas in need of restoration within the Entiat Basin. By increasing known areas in need of restoration, it is reasonable to assume that production of steelhead would increase.

Diversity

Because some areas within the Entiat Basin are in need of habitat improvements, diversity within the basin is believed to be lower than historic. While the Entiat population is still believed to be an independent population, increased habitat would most likely increase spatial and life history diversity.

Currently, genetic sampling has not found any differences among steelhead within the basin.

Table 18. Summary of steelhead presence in the Entiat subbasin

	Distribution	**Abundance**	**Productivity**	**Diversity**
Historic	High	Low-moderate	Moderate	High
Current	Mod-high	Low	Low	Moderate

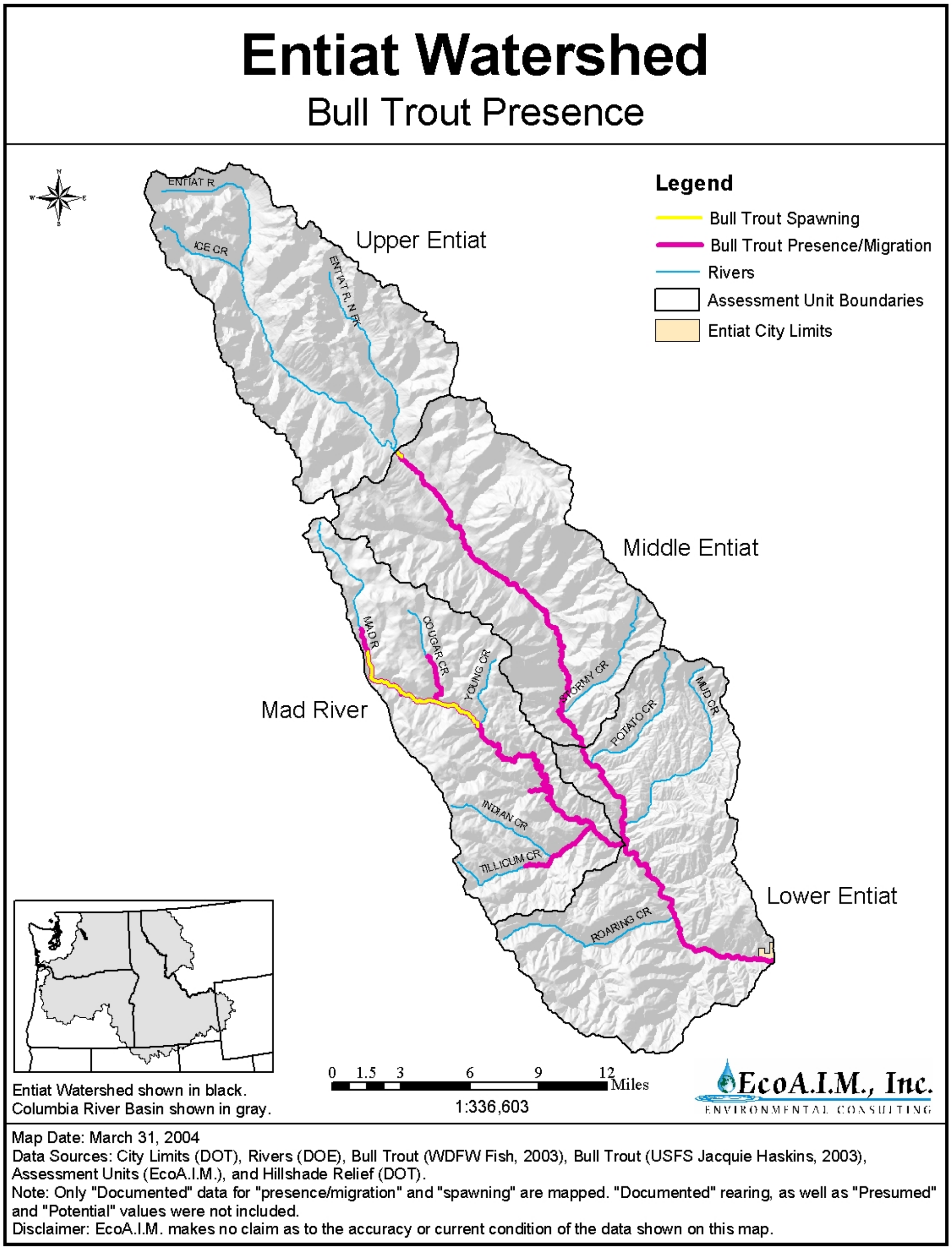


Figure 13. Bull trout distribution in the Entiat subbasin

4.8.6 Bull Trout (*Salvelnius confluentus*)

Rationale for Selection

The Entiat bull trout is included by the USFWS into the Columbia River distinct population segment (DPS) and are listed as threatened under the ESA. Bull trout are found throughout much of the Entiat subbasin, particularly in the mid and upper elevation streams, although it is not certain if these fish are able to establish themselves above Entiat Falls. Adults showing a fluvial life form use the mainstem as a migration, and possible feeding corridor. Bull trout are sensitive to environmental changes, especially water temperature making them a good biological indicator of ecosystem health in the mid and upper elevations.

Key Life History Strategies, Relationship to Habitat

Spawning

Bull trout spawn in the Entiat River basin from September through October based on FWS bull trout spawning surveys. The onset of spawning in a stream reach is temperature driven, apparently at the onset of dropping temperatures.

Prespawning

When adults are migrating upstream to spawning areas, they associate with cover; debris, deep pools, and undercut banks. The availability of and number of deep pools and cover is important to offset potential prespawning mortality. Intact riparian habitat will increase the likelihood of instream cover, and normative channel geofluvial processes will increase the occurrence of deeper pools.

Redd characteristics

Important habitat needs for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. Fraley and Shepard characterized selected areas as having low compaction and low gradient, and potentially near upwelling influences and proximity to cover. In general, mean velocities over redds range from 0.13-2.0 fps, with water depth ranging from 0.71-2.0 ft. Brown (1992) noted that these metrics comported well with those found within the Entiat Basin. Preservation or restoration of naturally occurring geofluvial function insures that the proper spawning habitat is available.

Incubation and emergence

Optimum incubation for bull trout is lower than other salmonids (2-4 °C; in Brown 1992). Because of the lower temperatures, bull trout development within the redd is usually longer than other salmonids. Emergence may take another three weeks after hatching.

Stream conditions (e.g., frequency of flooding, extreme low temperatures) may affect egg survival too. Floods can scour eggs from the gravel by increasing bedload movement. High flows associated with unstable stream banks increases sediment deposition that reduces oxygen and percolation through the redd. Healy (1991) cites Shaw and Maga

(1943) as showing that siltation may be more lethal earlier in the incubation period than in later phases.

In the Entiat Basin, fall flooding has a high frequency of occurrence. This may negatively affect incubation and emergence success, especially in years of extreme flows (e.g., 1990 and 1995). Road building activities in the upper watersheds may also increase siltation, as well as grazing and mining activities. All three factors were once more prevalent than they are now in the basin, and conditions have improved in most watersheds.

Because bull trout development within the redd takes a long period of time, they may be more vulnerable to increases in sediments or degradation other water quality (Fraley and Shepard 1989).

Fry

Fry (< 100 mm) are usually found in shallow, slow backwater side channels or eddies, in association with fine woody debris. Age-0 bull trout are consistently found near the substrate, usually over gravel-cobble areas.

Conservation and restoration of natural geofluvial processes and riparian areas of natal streams within the Entiat Basin would increase the type of habitat that fry utilize.

Parr

Hillman and Miller (2002) state that most juvenile bull trout are consistently found in multiple channels, pool, and riffles, and a few in glides. Juveniles were found in association with the stream bottom over rubble and small boulder substrate or near woody debris.

Downstream movement of juveniles (> 100 mm) from natal streams probably occurs within the Entiat Basin. Since 1992, sampling by WDFW has found bull trout emigrating from the Chiwawa River, having two modes; one in spring, and the other in the fall.

Movement of juvenile bull trout from the higher-order streams in the fall appears to be a response to the harsh conditions encountered in the upper tributaries. Murdoch et al. (2001) also speculated that movement in the fall may also be correlated to the size and age at which bull trout become piscivorous.

Conservation of high functioning habitat in natal tributaries, restoration of riparian and geofluvial processes in or near known and potential juvenile rearing areas will have the highest likelihood of increasing parr survival.

Another factor that may have impacts on bull trout production in the Entiat Basin is competition with brook trout. Brook trout are found in the upper Entiat, but may not be distributed throughout the basin (P. Archibald, USFS).

Population Characterization

Distribution

Historic

While detailed historic distribution is difficult to determine (Rieman et al. 1997), bull trout are believed to have been historically present in the Entiat River (Brown 1992; Mongillo 1993).

Current

The USFWS (2002) has identified two sub populations of bull trout in the Entiat River, one fluvial population in the mainstem Entiat and one in the Mad River, a tributary to the Entiat. Primary bull trout spawning and rearing areas are in the Mad River and the mainstem Entiat River from the Entiat Falls downstream to the National Forest boundary (USFWS 2002).

Abundance

Historic

There is currently no information available to assess what historic abundance of bull trout was in the Entiat River Basin.

Current

Bull trout redd surveys have been conducted by the USFS in the Entiat River Basin since 1989, primarily in the Mad River. Since 1989, the number of redds observed has averaged 24, and has increased, primarily since 1997. Archibald and Johnson (2002) attribute the increase in bull trout redds in the Mad River to the closure of bull trout fishing in 1992 and the closure to all fishing (from the mouth to Jimmy Creek) since 1995. USFWS has conducted bull trout redd surveys in the mainstem Entiat as an incidential observation during spring/summer Chinook spawning surveys. Starting in 2004, USFWS will begin a concerted effort to determine the extent of habitat use by spawning bull trout within the mainstem of the Entiat.

Productivity

Historic

Historic productivity of bull trout within the Entiat Basin is not known. However, it is reasonable to assume that it was higher, based on habitat degradation and management practices (harvest).

Current

Current productivity appears to be improving based on redd counts and other factors (see above).

Diversity

Historic diversity was most likely higher than current based on some habitat degradation and management practices. If habitat restoration occurs, there will most likely be an increase in spatial and potentially life history diversity.

Table 19. Summary of bull trout presence in the Enitat subbasin

	Distribution	Abundance	Productivity	Diversity
Historic	High	Moderate	Moderate	High
Current	Mod.-high	Low-moderate	Low-moderate	Mod.-high

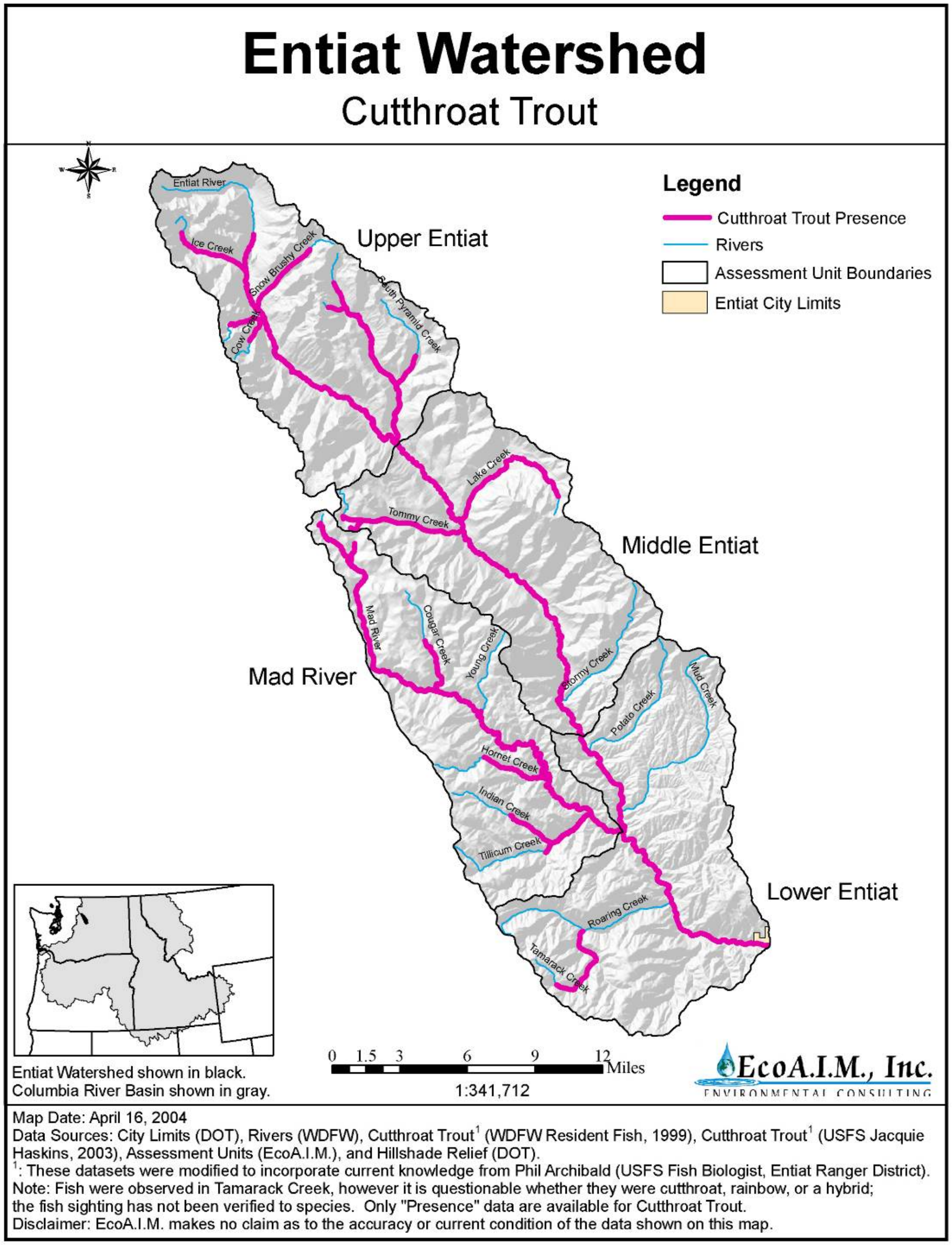


Figure 14. Westslope cutthroat trout distribution in the Entiat subbasin

4.8.7 Westslope Cutthroat Trout (*Oncorhynchus clarki lewisi*)

Rationale for Selection

Westslope cutthroat trout are known to exist throughout most of the high elevation streams within the Entiat subbasin. There are concerns about the status of this species due to genetic introgression (especially with introduced rainbow trout), depressed and fragmented populations or stocks, and loss of migratory life histories. The USFWS considers the westslope cutthroat trout a species of concern. The USFWS received a formal petition to list the westslope cutthroat trout as threatened pursuant to the ESA. A status review determined a listing of the species was not warranted at this time.

Cutthroat trout inhabit mid to high elevation streams, and may be the only salmonid species existing in various reaches. Cutthroat trout are sensitive to environmental changes, especially water temperature making them a good biological indicator of ecosystem health in the mid and upper elevations.

Key Life History Strategies, Relationship to Habitat

Spawning

Westslope cutthroat trout (WSCT) spawn between March and July, when water temperatures begin to warm. Spawning and rearing streams tend to be cold and nutrient poor.

Prespawning

When adults are migrating upstream to spawning areas, they associate with cover; debris, deep pools, and undercut banks. The availability of and number of deep pools and cover is important to offset potential prespawning mortality. Adult cutthroat trout need deep, slow moving pools that do not fill with anchor ice in order to survive the winter. Intact riparian habitat will increase the likelihood of instream cover, and normative channel geofluvial processes will increase the occurrence of deeper pools.

Redd characteristics

Important habitat needs for redd building include the availability of clean gravel at the appropriate size, and proper water depth and velocity. USFWS (1992) state that WSCT redds are usually found in water that is about 0.7 ft deep with mean velocities of 1.0 to 1.3 fps.

Incubation and emergence

Eggs incubate for several weeks and emergence occurs several days after hatching (USFWS 1999).

Stream conditions (e.g., frequency of flooding, extreme low temperatures) may affect egg survival too. Floods can scour eggs from the gravel by increasing bedload movement. High flows associated with unstable stream banks increases sediment deposition that reduces oxygen and percolation through the redd. Healy (1991) cites Shaw and Maga (1943) as showing that siltation may be more lethal earlier in the incubation period than in later phases.

In the Entiat Basin, fall flooding has a high frequency of occurrence. This may negatively affect incubation and emergence success, especially in years of extreme flows (e.g., 1990 and 1995). Road building activities in the upper watersheds may also increase siltation, as well as grazing and mining activities. All three factors were once more prevalent than they are now in the basin, and conditions have improved in most watersheds.

Fry

After emergence, fry are usually found in shallow, slow backwater side channels or eddies, in association with fine woody debris.

Conservation and restoration of natural geofluvial processes and riparian areas of natal streams within the Entiat Basin would increase the type of habitat that fry utilize.

Parr

Juvenile cutthroat trout overwinter in the interstitial spaces of large stream substrate.

Hillman and Miller (2002) state that most juvenile WSCT are consistently found in multiple channels and pools.

Downstream movement of juveniles from natal streams probably occurs within the Entiat Basin.

Movement of juvenile WSCT within streams is most likely related to changing habitat requirements as the fish grows, or winter refuge.

Conservation of high functioning habitat in natal tributaries, restoration of riparian and geofluvial processes in or near known and potential juvenile rearing areas will have the highest likelihood of increasing parr survival.

Another factor that may have impacts on bull trout production in the Entiat Basin is competition with brook trout. Brook trout are found in the upper Entiat, but may not be distributed throughout the basin (P. Archibald, USFS).

Population Characterization

Distribution

Historic

The primary historic distribution of westslope cutthroat trout (WSCT) occurred in the upper Columbia and Missouri River basins (USFWS 1999). WSCT were originally believed to occur in three river basins within Washington State; Methow, Chelan, and Pend Oreille, although only abundant in the Lake Chelan Basin (Williams 1998). From Williams (1998):

Apart from Lake Chelan and the Pend Oreille River where an abundance of relatively large cutthroat commanded the attention of pioneers, cutthroat trout in streams were obscured by their headwater location and small body size . . . Accordingly, the ethnohistorical record is mostly silent on the presence or absence of cutthroat. The picture is further blurred by the early scattering of cutthroat from the first trout hatchery in Washington (Stehekin River Hatchery, 1903) by entities (Department of Fisheries and

Game and county Fish Commissions) dissolved decades ago along with their planting records. The undocumented translocation of cutthroats by interested non-professional starting with pioneers is another confusing factor that challenges determination of historical distribution.

Recent information, based on further genetic analyses (Trotter et al. 2001; Behnke 2002; Howell et al. 2003), indicates that the historic range of WSCT in Washington State is now believed to be broader. Historic distribution now includes the headwaters of the Entiat and Yakima River basins (Behnke 2002).

Overall, Behnke (1992) believed that the disjunct populations in Washington State probably were transported here through the catastrophic ice-age floods.

Current

Through stocking programs that began with Washington state's first trout hatchery in the Stehekin River valley in 1903 (that targeted WSCT), WSCT have been transplanted in almost all available stream and lake habitat (Williams 1998).

In the Entiat, WSCT sustain themselves in 80 miles within 16 streams and 140 acres in 8 lakes (Williams 1998).

Abundance

Historic

There is currently no information available to assess what historic abundance of WSCT was in the Entiat River Basin. Numerical abundance has not been documented or estimated for WSCT. Westslope cutthroat were not thought to have been very abundant where they occurred in the headwater locations within the Methow, Entiat, and Entiat basins (Williams 1998; USFWS 1999; Behnke 2002).

Current

There are no known estimates of current abundance within the Entiat River Basin

Productivity

Historic

Historic productivity of WSCT trout within the Entiat Basin is not known. However, it is reasonable to assume that it was higher, based on habitat degradation and management practices (hatchery plants).

Current

There are no known estimates of current abundance within the Entiat River Basin.

Diversity

Historic diversity was most likely higher than current based on some habitat degradation. If habitat restoration occurs, there will most likely be an increase in spatial and potentially life history diversity.

Table 20. Summary of westslope cutthroat trout presence in the Entiat subbasin

	Distribution	Abundance	Productivity	Diversity
Historic	Low-Moderate	Low	Moderate	High
Current	Low-Moderate	Low	Low-Moderate	Moderate-High

4.8.8 Pacific Lamprey (*Lampetra tridentate*)

Rationale for Selection

Very little is known about Pacific lamprey populations or stocks in the Upper Columbia and the Entiat. Pacific lamprey is a culturally and commercially important specis to the Yakima Nation and the Confederated Tribes of the Colville Reservation. Pacfic lamprey is also been listed by the USFWS as a species of conern.

Key Life History Strategies, Relationship to Habitat

Distribution

Historic

Historical distribution of Pacific lamprey in the Columbia and Snake Rivers was coincident wherever salmon occurred (Simpson and Wallace 1978). It is likely that Pacific lamprey occurred historically within the Entiat Basin. If we assume that Pacific lamprey and salmon used the same streams, one could conclude that Pacific lamprey occurred in the mainstem Entiat and Mad Rivers.

Current

Pacific lamprey still exist in the Entiat system, but the distribution is mostly unknown. BioAnalysts (2000) used anecdotal information to describe the extent of Pacific lamprey distribution Entiat Basin. However, they cautioned that the following description may be confounded by the presence of river lamprey. In most cases, observers they cited reported the occurrence of lamprey but did not identify the species. Thus, the descriptions below may apply to both species. Juvenile lamprey have been found near RM 16, within the hatchery, and near the mouth (BioAnalysts 2000).

Abundance

Historical abundance of Pacific lamprey is difficult to determine because of the lack of specific information. However, lamprey were (and continue to be) culturally significant to the Native American tribes in the Columbia Basin.

Current

There are currently no abundance information except perhaps dam count differences between Rocky Reach and Wells. However, comparing counts among different projects is problematic because of sampling inconsistencies, the behavior of lamprey in counting stations, and the ability of lamprey to bypass counting stations undetected (BioAnalysts 2000).

Productivity

There currently is no information on historic and current productivity on Pacific lamprey. However, it is reasonable to assume that current production is lower than historic.

Diversity

Current distribution within the Entiat Basin may be impacted within smaller tributaries, but this is not known. Current diversity is most likely similar to historic.

Table 21. Summary of Pacific lamprey presence in the Entiat subbasin

	Distribution	Abundance	Productivity	Diversity
Historic	Higher than present	Higher than present	Higher than present	?
Current	?	?	?	?

4.9 Relationships of Salmonid Populations to the Ecosystem

4.9.1 Introduction

The biotic communities of aquatic systems in the Upper Columbia Basin are highly complex. Within communities, assemblages and species have varying levels of interaction with one another. Direct interactions may occur in the form of predator-prey, competitor, and disease- or parasite-host relationships. In addition, many indirect interactions may occur between species. For example, predation of one species upon another may enhance the ability of a third species to persist in the community by releasing it from predatory or competitive constraints. These interactions continually change in response to shifting environmental and biotic conditions. Human activities that change the environment, the frequency and intensity of disturbance, or species composition can shift the competitive balance among species, alter predatory interactions, and change disease susceptibility. All of these changes may result in community reorganization.

Community Structure

Few studies have examined the fish species assemblages within the Upper Columbia Basin. Most information available is from past surveys, dam passage studies, and northern pikeminnow studies. The available information indicates that about 41 species of fish occur within the Upper Columbia Basin (from the mouth of the Yakama River upstream to Chief Joseph Dam). This is an underestimate because several species of cottids (sculpins) live there. Of the fishes in the basin, 15 are cold-water species, 18 are cool-water species, and 8 are warm-water species. Most of the cold-water species are native to the area; only four were introduced (brown trout (Salmo trutta), brook trout (Salvelinus fontinalis), lake whitefish (Coregonus clupeaformis), and Atlantic salmon (S. salar). Four of the 18 cool-water species are exotics (pumpkinseed (Lepomis gibbosus), walleye (Stizostedion vitreum), yellow perch (Perca flavescens), and smallmouth bass (Micropterus dolomieu)), while all warm-water species are exotics.

About half of the resident species in the upper basin are piscivorous or fish eating. Ten cold-water species, 7 cool-water species, and 5 warm-water species are known to eat fish. About 59% of these piscivores are exotics. Before the introduction of exotics, northern pikeminnow (Ptychocheilus oregonensis), sculpin (Cottus spp.), white sturgeon, bull trout (Salvelinus confluentus), rainbow trout (O. mykiss), cutthroat trout (O. clarki), and burbot (Lota lota) were the primary piscivores in the region. Presently, burbot are rare in the upper basin and probably have little effect on the abundance of juvenile salmonids in the region. The status of white sturgeon in the upper basin is mostly unknown, although their numbers appear to be quite low.

Introduced species such as walleye, smallmouth bass, and channel catfish (Ictalurus punctatus) are important predators of salmonids in the Columbia River. Channel catfish are rare and likely have little to no effect on abundance of salmonids. Other piscivores, such as largemouth bass (M. salmoides), black crappie (Pomoxis nigromaculatus), bluegill (Lepomis macrochirus), brown bullhead (Ameiurus nebulosus), yellow perch, and pumpkinseed are either rare or not known to prey heavily on juvenile anadromous fish.

What follows is a more detailed discussion of interactions between fish, birds, and mammals and spring chinook and summer steelhead in the Upper Columbia Basin.

Competition

Competition among organisms occurs when two or more individuals use the same resources and when availability of those resources is limited. That is, for competition to occur, demand for food or space must be greater than supply (implies high recruitment or that the habitat is fully seeded) and environmental stresses few and predictable. Two types of competition are generally recognized: (1) interference competition, where one organism directly prevents another from using a resource through aggressive behavior, and (2) exploitation competition, where one species affects another by using a resource more efficiently. Although competition is difficult to demonstrate, a few studies conducted within the Upper Columbia Basin indicate that competition may affect the production of chinook salmon and steelhead in the basin.

Chinook/steelhead

Perhaps the most likely form of interspecific competition would be between juvenile chinook and steelhead. Hillman et al. (1989) investigated the interaction between juvenile chinook and steelhead in the Entiat River between 1986 and 1989. They reported that chinook and steelhead used dissimilar daytime and nighttime habitat throughout the year. During the daytime in summer and autumn, juvenile chinook selected deeper and faster water than steelhead. Chinook readily selected stations associated with brush and woody debris for cover, while steelhead primarily occupied stations near cobble and boulder cover. During winter days, chinook and steelhead used similar habitat, but Hillman et al. did not find them together. At night during both summer and winter, Hillman et al. found that both species occupied similar water velocities, but subyearling chinook selected deeper water than steelhead. Within smaller streams, chinook were more often associated with pools and woody debris during the summer, while steelhead occurred more frequently in riffle habitat. Hillman et al. (1989) concluded that interaction between the two species would not strongly negatively affect production of either species, because disparate times of spawning tended to segregate the two species. This conclusion is consistent with the work of Everest and Chapman (1972) in Idaho streams.

Redside shiners

Under appropriate conditions, interspecific interaction may also occur between redside shiners and juvenile salmon and trout. Hillman (1991) studied the influence of water temperature on the spatial interaction between juvenile chinook and redside shiners in the field and laboratory. In the Entiat River during summer, Hillman (1991) noted that chinook and shiners clustered together and that shiners were aggressive toward salmon. He reported that the shiners used the more energetically profitable positions, and that they remained closer than chinook to instream and overhead cover. In laboratory channels, shiners affected the distribution, activity, and production of chinook in warm (64-68°F) water, but not in cold (54-59°F) water (Hillman 1991). In contrast, chinook influenced the distribution, activity, and production of shiners in cold water, but not in warm water. Reeves et al. (1987) documented similar results when they studied the interactions between redside shiners and juvenile steelhead. Although Hillman (1991) conducted his fieldwork in the lower Entiat River, shiners are also present in the Entiat, Methow, and Okanogan rivers and are abundant in the mainstem Columbia River. At warmer temperatures, shiners likely negatively affect the production of chinook salmon and steelhead in the upper basin.

Coho salmon

It is unknown if the re-introduction of coho salmon into the Upper Columbia Basin may affect the production of chinook and steelhead, although the results of extensive predation and competition studies associated with the YN's current reintroduction efforts indicate that the reintroduction of coho is unlikely to negatively affect production of chinook and steelhead. One of the first studies in the upper basin that addressed effects of coho on chinook and steelhead production was conducted by Spaulding et al. (1989) in the Wenatchee River. This work demonstrated that the introduction of coho into sites with naturally produced chinook and steelhead did not affect chinook or steelhead abundance or growth. However, because chinook and coho used similar habitat, the introduction of coho caused chinook to change habitat. After removing coho from the sites, chinook moved back into the habitat they used prior to the introduction of coho. Steelhead, on the other hand, remained spatially segregated from chinook and coho throughout the study. More recent studies conducted by Murdoch et al. (2004) found that juvenile coho, chinook, and steelhead used different microhabitats in Nason Creek, and at the densities tested, coho did not appear to displace juvenile chinook or steelhead from preferred microhabitats.

Various salmonids

Most adult salmonids within the upper basin are capable of preying on juvenile chinook and steelhead. Those likely to have some effect on the survival of chinook and steelhead include adult bull trout, rainbow/steelhead trout, cutthroat trout, brook trout, and brown trout. Because brown trout are rare in the region, they probably have little effect on the survival of other salmonids. The other salmonids often occur in the same areas as chinook and steelhead and are known to be important predators of chinook and steelhead (Mullan et al. 1992). Of these, bull trout and rainbow trout are probably the most important. These species occur together in most tributaries; hence the probability for interaction is high. The presence of both fluvial and adfluvial stocks of bull trout in the region further increases the likelihood for interaction there.

Bull trout are opportunistic feeders and will eat just about anything including squirrels, birds, ducklings, snakes, mice, frogs, fish, and insects (Elliott and Peck 1980; Goetz 1989), although adult migrant bull trout eat primarily fish. Because adult migrant bull trout occur throughout the upper basin, including the mainstem Columbia River (Stevenson et al. 2003), they likely prey on juvenile salmonids. In the upper Wenatchee Basin, Hillman and Miller (2002) noted that juvenile chinook and steelhead were rare in areas where adult bull trout were present. Like northern pikeminnow, adult bull trout frequent the tailrace areas of Upper Columbia dams. These areas provide concentrated prey items, which include juvenile chinook and steelhead. It is likely that adult bull trout prey heavily on migrant salmon and steelhead in these areas. Indeed, Stevenson et al. (2003) found bull trout staging near the Wells Hatchery outfall, apparently seeking opportunistic feeding opportunities. As the number of bull trout increase in the upper basin, the interaction between them and salmon and steelhead will increase.

Rainbow/steelhead trout feed on chinook fry in the upper basin. In the Wenatchee River, for example, Hillman et al. (1989) observed both wild and hatchery rainbow/steelhead feeding on chinook fry. Predation was most intense during dawn to dusk. At that time, rainbow/steelhead occupied stations immediately adjacent to aggregations of chinook. Hillman et al. (1989) noted that within the prey cluster, the largest, light-colored chinook were closest to shelter and seldom eaten. Small, darker-colored chinook were farther from escape cover and usually eaten by predators. Hillman et al. (1989) suggest that predator-mediated interaction for shelter was strong and contributed to the rapid decline in chinook numbers in May. Although this work was done in the Wenatchee River, the results probably hold for other tributaries where the two species occur together.

Although adult salmonids prey on juvenile salmonids in the upper basin, the predation rate is unknown. Because of the abundance of both bull trout and rainbow/steelhead trout in the upper basin, it is reasonable to assume that large numbers of fry are consumed by these fish.

Predation

Fish, mammals, and birds are the primary natural predators of salmonids in the Upper Columbia Basin. Although the behavior of various salmonids precludes any single predator from focusing exclusively on them, predation by certain species can nonetheless be seasonally and locally important. Recent changes in predator and prey populations along with major changes in the environment, both related and unrelated to development in the Mid-Columbia Basin, have reshaped the role of predation.

Although several fish species can consume salmonids in the upper basin, northern pikeminnow, walleyes, and smallmouth bass have the potential for significantly affecting the abundance of juvenile anadromous fish. These are large, opportunistic predators that feed on a variety of prey and switch their feeding patterns when spatially or temporally segregated from a commonly consumed prey. Channel catfish also have the potential to significantly affect the abundance of juvenile salmonids, but because they are rare in the Upper Columbia, they likely have a small effect on survival of juvenile salmonids there. Native species such as sculpins and white sturgeon also prey on juvenile anadromous fish. Below is a discussion on the importance of specific predators on the production of salmonids in the Upper Columbia Basin.

Sculpins

Sculpins are native and relatively common in the upper basin. Although sculpins are not considered a major predator of outmigrating anadromous fish, they do prey on small chinook and steelhead. In the Entiat River, Hillman (1989) noted that large concentrations (20 fish/11 sq. ft.) of juvenile chinook and steelhead occupied inshore, shallow, quiet-water positions on the streambed during the night. Hillman (1989) found that many sculpins moved into these areas at night and preyed heavily on chinook and steelhead fry. Predation on fry appeared to be limited to sculpins larger than 3.3 in. and ceased when prey reached a size larger than 2 in. The number of fry eaten per night appeared to be related to sculpin size, with the largest sculpins consuming the most fry per individual.

Because sculpins are abundant in Upper Columbia River tributaries, they are likely an important agent of mortality of salmonid eggs and fry. As chinook and steelhead fry grow, they are released from this source of mortality. It is unknown what fraction of the chinook and steelhead population is removed by sculpins.

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Birds

Currently, there is little information on the effects of bird predation on the abundance of juvenile salmon and trout in the upper basin. Fish-eating birds that occur in the project area include great blue herons (Ardea herodias), gulls, osprey (Pandion haliaetus), common mergansers (Mergus merganser), American dippers (Cinclus mexicanus), cormorants (Phalacrocorax spp.), Caspian terns, belted kingfishers (Ceryle alcyon), common loons (Gavia immer), western grebes (Aechmophorus occidentalis), black-crowned night herons (Nycticorax nycticorax), and bald eagles (Haliaeetus leucocephalus). According to Wood (1987a, 1987b), the common merganser limited salmon production in nursery areas in British Columbia. He found during smolt migrations that mergansers foraged almost exclusively on juvenile salmonids (Wood 1987a). Maximum mortality rate declined as fish abundance increased (i.e., dispensatory mortality) and did not exceed 10% for any salmonid species. Wood (1987b) also estimated that young mergansers consumed almost one-half pound of subyearling chinook per day. Thus, a brood of ten ducklings could consume between four and five pounds of fish daily during the summer.

Cormorants may take large numbers of juvenile salmon and trout in the upper basin. Roby et al. (1998) estimated that cormorants in the estuary consumed from 2.6 to 5.4 million smolts in 1997, roughly 24% of their diet, and most were hatchery fish. Although Caspian terns are not common in the project area, there is evidence that they consume fish from the project area. Bickford found both PIT-tags and radio tags at a Caspian Tern nesting area near Moses Lake. Tag codes indicated that consumed fish were from the Upper Columbia region (Peven 2003).

Mammals

No one has studied the influence of mammals on numbers of juvenile chinook in the Upper Columbia Basin. Observations by Ashley and Stovall indicate that river otters (Lutra Canadensis) occur throughout the region. BioAnalysts found evidence of otters fishing the Entiat, Chiwawa, Entiat, and Methow rivers, and Icicle Creek. Otters typically fished in pools with LWD. According to Hillman and Miller (2002), juvenile chinook are most abundant in these pool types, thus, the probability for an encounter is high. Dolloff (1993) examined over 8,000 otoliths in scats of two river otters during spring 1985 and found that at least 3,300 juvenile salmonids were eaten by them in the Kadashan River system, Alaska. He notes that the true number of fish eaten was much higher, as it is unlikely that searchers found all the scats deposited by the otters. Other predators, such as raccoon (Procyon lotor) and mink (Mustela vison) also occur in tributaries throughout the Upper Columbia Basin. Their effects on numbers of salmon and trout are unknown.

Black bears (*Ursus americanus*) are relatively common in the Upper Columbia Basin and frequent streams used by spawning salmon during autumn. Studies have shown that salmon are one of the most important meat sources of bears and that the availability of salmon greatly influences habitat quality for bears at both the individual level and the population level. Observations by crews conducting chinook spawning surveys in the upper basin indicate that bears eat chinook, but it is unknown if the bears remove per-spawned fish or are simply scavenging post-spawned fish. Regardless, there is no information on the roll that bears play in limiting survival and production of salmon and trout in the upper basin.

4.10 Aquatic Habitat Conditions

4.10.1 Assessment Methodology

Recently, the Entiat Watershed Planning Unit Habitat Subcommittee members worked with Mobrand Biometrics, Inc. to model Chinook salmon response to various restoration scenarios using the Ecosystem Diagnosis and Treatment (EDT) methodology. Time and funding resources were not available to complete other species analysis.

EDT is an analytical method relating habitat features and biological performance to support conservation and recovery planning. It acts as an analytical framework that brings together information from empirical observation, stakeholders and local experts, and other models and analyses tools.

This section presents the initial EDT "Diagnosis" for planning restoration and protection of salmon habitat in the Entiat River subbasin. The Diagnosis is based on an assessment of the relative contributions of environmental factors to the biologic performance of naturally produced Chinook salmon.

The EDT analysis consisted of two phases with unique objectives:

> Watershed Assessment (Diagnosis): To complete a watershed assessment with respect to Chinook salmon (the focal or diagnostic species selected for the Entiat), assessing current and historic measures of population performance relative to habitat conditions, and to derive strategic priorities for protection and restoration actions.

> Analysis of Action Alternatives (Treatment): To assess how various future management actions might contribute to the long-term enhancement or restoration of biologic productivity of salmonid species – specifically Chinook salmon.

In the assessment phase, the EWPU Habitat subcommittee characterized baseline reference conditions with regard to both environmental conditions and population performance measures. Two baseline reference scenarios were characterized: historic (predevelopment) conditions and current conditions. The comparison of these scenarios forms the basis of the diagnostic conclusions about how the Entiat subbasin and associated salmon performance have been altered by human development. The historic reference scenario also serves to define the natural limits to potential recovery actions within the subbasin.

During the analysis of action alternatives, five alternative management scenarios were modeled. These alternatives were based on and consistent with alternatives developed and outlined in the Entiat River Inventory and Analysis (CCCD 1998), and contained in the Entiat Final Coordinated Resource Management Plan/First Draft WRIA 46 Management Plan (CCCD 2002).

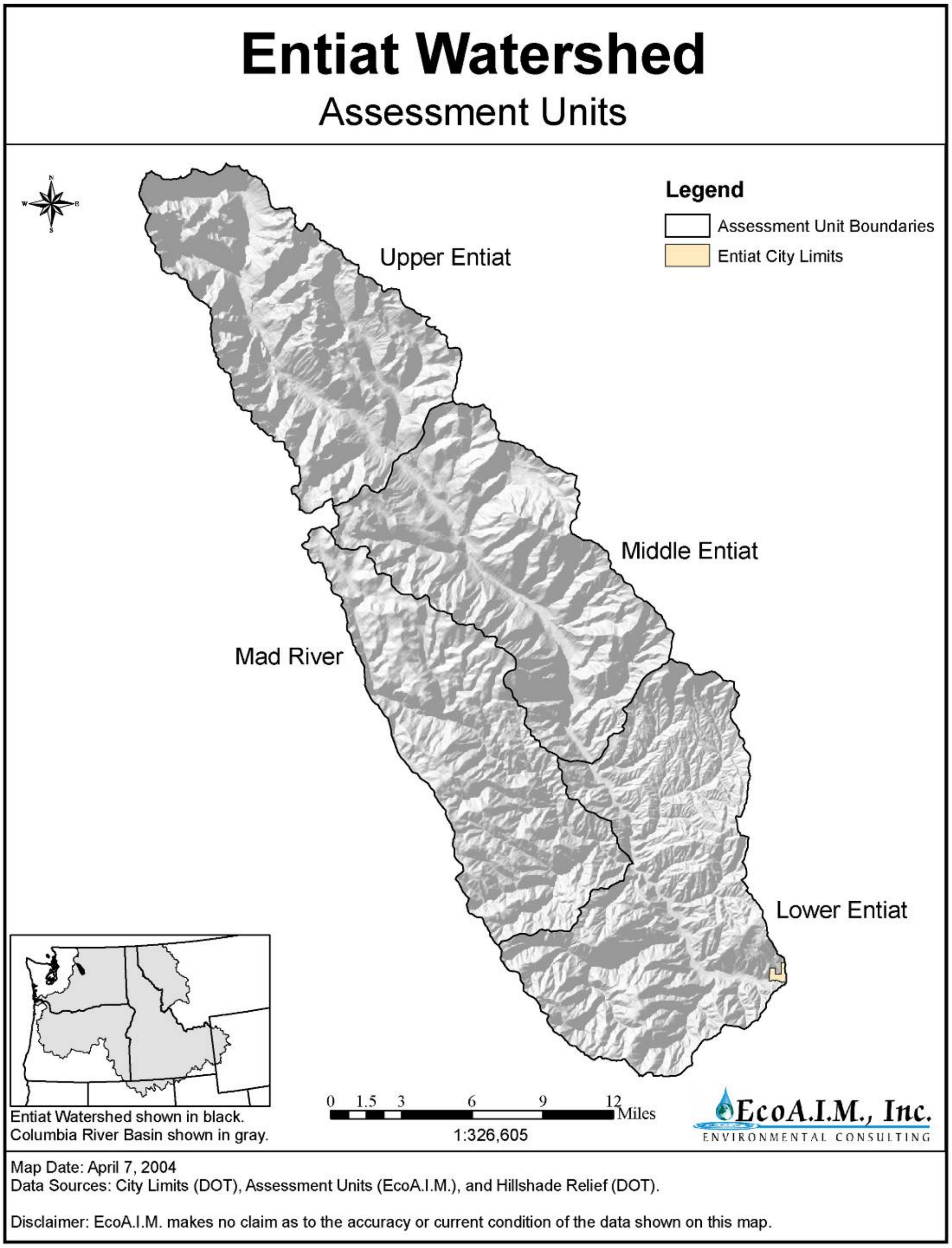

Figure 15. Assessment units in the Entiat subbasin

Basis of the EDT Analysis

As mentioned above, the EDT analysis describes how certain salmonid populations interact with their environment, relative to habitat conditions. The EWPU Habitat Subcommittee defined 24 specific stream reaches within the Entiat subbasin used by Chinook salmon, and evaluated approximately 40 habitat attributes for each of these reaches. The Planning Unit also performed field site visits to validate habitat condition assumptions against current conditions.

Because of the substantial complexity of how well various life stages of Chinook salmon survive in different reaches at different times of the year, a computer-based computational model is necessary to track all of the interactions and assumptions to provide resource managers defensible decision-making tools. The primary output of the EDT modeling process describes a population's "biological performance" (in this case, the Entiat spring Chinook and Entiat summer [late-run] Chinook populations) with respect to the different treatments.

Biological performance can be defined in terms of three elements: 1) biologic productivity, 2) environmental capacity, and 3) life history diversity. These measures are characteristics of the ecosystem that describes a population's persistence, abundance, and distribution potential. These three elements are also the core performance measures used by the NOAA Fisheries (formerly NOAA National Marine Fisheries Service) as part of its viable population concept. Each measure is defined briefly below

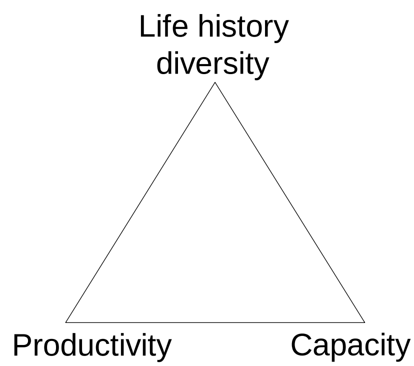

Figure 16. Three core performance measures of biological performance

<u>Productivity</u>. This element represents the relative success of the species to complete its life cycle within the environment it experiences. It determines resilience to mortality pressures, such as from fishing, dams, and further habitat degradation. Habitat quality (including water quality) is a major determinant of a population's productivity. (*The productivity rate is the reproductive rate measured over a full generation that would occur at low population density, i.e., when competition for resources among the population is minimal.)*

<u>Capacity</u>. This element defines how large a population can grow within the environment it experiences, as a result of finite space and food resources. It determines the effect of this upper limit on abundance to survival and distribution. *Habitat quantity* is a major determinant of the environmental capacity to support population abundance.

Life History Diversity. This element represents the multitude of pathways through space and time available to, and used by, a species in completing its life cycle. Populations that can sustain a wide variety of life history patterns are likely to be more resilient to the influences of environmental change. Thus a loss of life history diversity is an indication of declining health of a population and perhaps its environment.

Assessment Units

The Entiat subbasin is very diverse in elevation and environmental conditions. While the subbasin contains some of the most pristine habitat found throughout the Columbia River basin, it experienced considerable habitat degradation in the lower portions of the drainage. For the purposes of this assessment, the Entiat Subbasin has been dissected into four distinct Assessment Units, indicated below:

1. Lower Entiat River Assessment Unit extends from the mouth of the mainstem Entiat River to the Potato Moraine.
2. Middle Entiat River Assessment Unit extends from the Potato Moraine to Entiat Falls (upper extent of anadromous fish).
3. Upper Entiat River Assessment unit extends from Entiat Falls to the headwater streams.
4. Made River Assessment Unit extends from its confluence with the Entiat River to its headwaters.

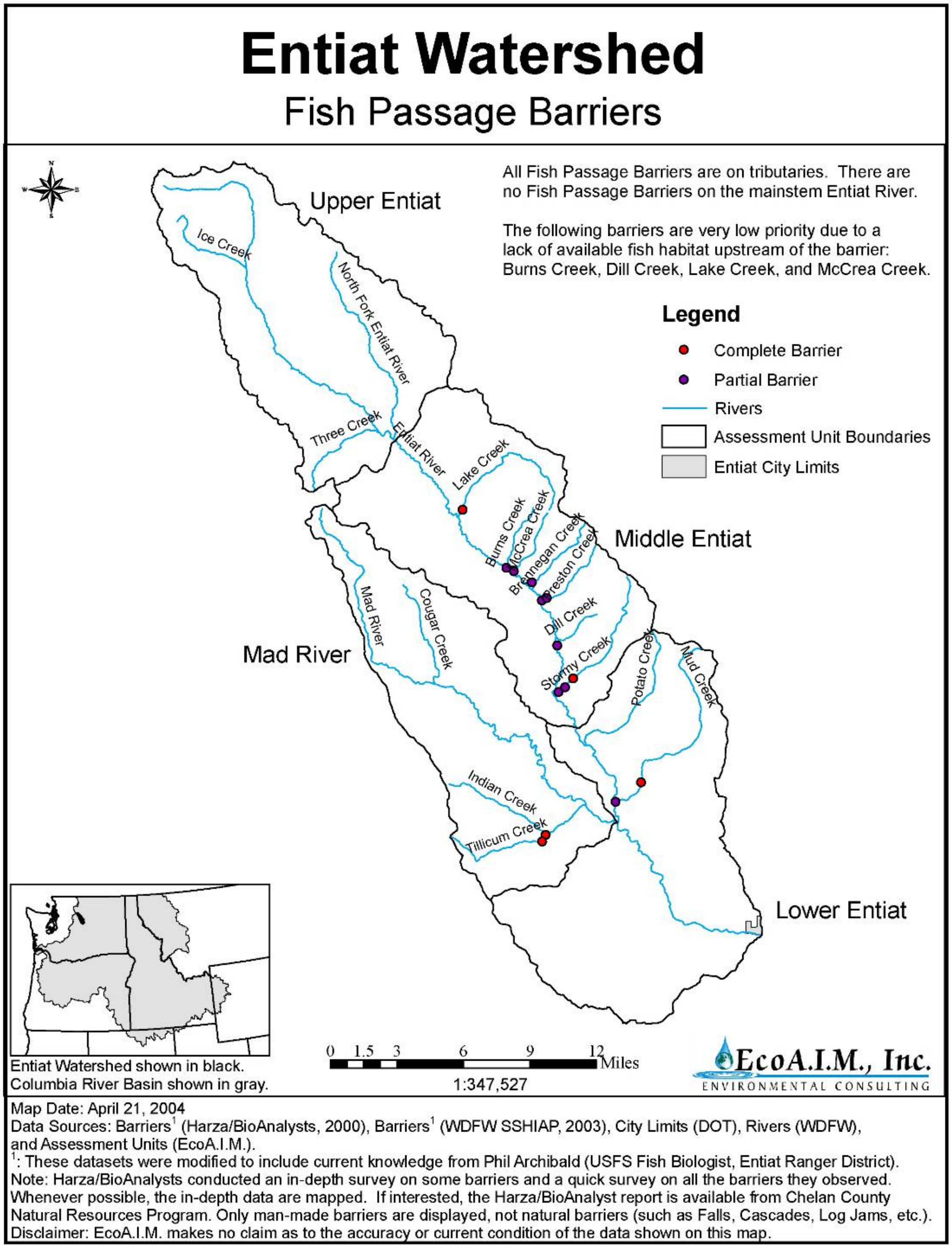

Figure 17. Fish passage barriers in the Entiat subbasin

4.10.2 Lower Entiat River Assesment Unit

Assessment Unit Description

The Lower Entiat Assessment Unit includes lesser tributaries and mainstem river from the Potato Moraine at RM 16.2 to the Entiat's confluence with the Columbia River (elevation 713 feet) at RM 0.0. The primary tributaries include Potato, Mud and Roaring Creeks.

Topography is characterized by non-glaciated mountain slopes strongly dissected by relatively high density, low order tributary streams. Steep, narrow V-shaped fluvial valleys are characteristic, with side slopes commonly ranging from 30-60%. Much of the AU is privately owned with most developments adjacent to the Entiat River and bottoms of the tributaries. Primary land use includes irrigated orchard and pasture. Significant urban development is limited to the city of Entiat (approximately 960 people).

Precipitation ranges from around 30" in tributary headwater areas to less then 10" along the Columbia River, with about 20-24" falling in the valley bottom. Approximately 75% of total precipitation falls from October through March. Most winter precipitation falls as snow; however, rain is not unusual at lower elevations. Temperatures can be extreme during both summer and winter months.

Assessment Unit Condition

The Entiat valley has been influenced by many natural disturbance events such as wildfire, flooding, earthquakes, landslides, glaciation, and volcanic eruptions (CCCD, 2004). Human influences have altered riparian and upland conditions, primarily from timber harvest, fire suppression, and livestock grazing (Archibald et al., 2002). Road construction, residential and agricultural development within the riparian zone has reduced or eliminated vegetation in many areas, and diminished sources of large wood recruitment as well as shade. Most of the mainstem Entiat River has been substantially altered due to channelization and flood control measures implemented in the 1950's, resulting in a simplified channel with little structural complexity that would benefit salmonid production. Culverts on some tributaries have created barriers for fish (Figure 17). Although soils are highly erodible and sediment deposition is a dominant natural process within this zone, removal of vegetation and surface soil disturbances has exacerbated fine sediment delivery and stream bank instability in areas.

Water Quality

Water quality for the lower mainstem Entiat River is generally in good to excellent condition, although it has been affected in the past by land management practices mentioned above. Tributaries and the portion of the mainstem Entiat River within the lower Entiat River assessment unit are classified as Class A (excellent) under state water quality standards.

USFS temperature data collected annually since the early 1990's show exceedences of state water quality temperature standard during July - September for each year of monitoring. Monitoring has also indicated that pH levels occasionally exceed state standards in this Assessment Unit, although these levels are believed to be at natural condition. Due to excursions beyond water quality standards, the lower mainstem Entiat was on the State's 303(d) list from 1992 until the 2002/2004 list:

Washington state 303d listings in the Entiat subbasin

Biennial List Year	Parameter(s) Listed
1992	pH
1994	pH and temperature
1996	pH, temperature, instream flow
1998	Instream flow
2000	n/a; the EPA did not require states to submit a 303(d) list in 2000.
	Temperature

Occasional temperature exceedences may have occurred naturally prior to settlement of the Entiat valley; however, the number and frequency of exceedences is likely elevated from natural levels due to a combination of decreased riparian vegetation/shade as a result of flood, development, and wildfire events and increased width-to-depth ratios due to past channelization/flood control projects.

High summer stream temperatures are likely increased during low flow years due to irrigation water withdrawals. The Stream Network Temperature Model developed for the Entiat River showed that increases in riparian shade would moderate instream temperatures during late summer months (Hendrick and Monahan, 2003).

Very cold winter temperatures are a natural occurrence. Frazil and anchor ice are a common winter phenomena, and can occupy most of the substrate in lower reaches in cold winters following dry summers. Winter water temperatures are likely lower than historic conditions due to altered riparian and in-channel conditions. Continuous water temperature monitoring at Entiat RM 1.4 (Keystone gage) since March 2002 shows extended periods (19 days) of minimum temperatures below 42.5º F during the late-run Chinook spawning period of October through early November. Entiat River winter (incubating) minimum stream temperatures were ≤ 33º F for prolonged periods (32 days) during the winter of 2002-2003.

BioAnalysts, Inc. (2002) evaluated water temperature, dissolved oxygen (intragravel and water column), and egg/alevin mortality in 24 chinook redds in the lower 3.5 miles of the Entiat River weekly during a study period from 11/18/2001 through 12/29/2001 and biweekly from 1/6/2002 through 3/23/2002. Trend analysis indicated that the survival of chinook within redds decreased significantly during the study period. The highest egg mortality (76% of 160 eggs sampled) occurred during the week of 1/6-12/2002 when intragravel DO was 12.15 mg/L, and mean daily water temperatures ranged between 1º C and 2.5º C. Entiat River Chinook fry did not emerge until late April, likely due to colder water temperatures (BioAnalysts, Inc. 2002).

Contaminants

A large portion of the subbasin's residential land and the majority of irrigated cropland are located along in the lower Entiat River valley. Consequently, the use of herbicides and pesticides in lower Entiat could impact riparian areas, water quality, and focal species health. However, no indication of water quality degradation due to chemical inputs has been noted at the WDOE ambient water quality station (46A070) near the mouth (RM 1.4) of the Entiat River

Results of tests for toxic materials, based on samples from two suckers (Catostomaus sp.) collected in the slack water area near the mouth of the Entiat, showed elevated levels of total DDT (4,4 DDT; 2,4 DDD and DDE) and its breakdown products. Low levels of HCB and PCB's were also detected (Davis and Serdar, 1996). Because fish sampled may have accumulated these toxic materials while residing in the Columbia River, tests are considered inconclusive and information concerning bio-accumulation of toxic materials is lacking.

Fecal coli form levels are generally within acceptable limits however, occasional exceedences of Clean Water Act standards have occurred (CCCD, 2003). Although fecal coli form counts have been and continue to be low, future growth in the Entiat valley may present the potential for water quality problems associated with septic systems. Unrestricted livestock access to streams and increases in the number of hobby farms/ranchettes have the potential to result in elevated fecal coli form levels.

The Entiat National Fish Hatchery is known to contribute waste materials directly to the Entiat River . There is no empirical information available to indicate the effect of hatchery effluence to the downstream environment.

Fine Sediment

The lower Entiat River is a relatively low gradient stream allowing for increased sediment deposition. Due to watershed and riparian conditions mentioned above, sediment and cobble embeddedness levels appear to be higher than expected. The 11-year average for measured fine sediments (less than 1mm diameter) in the lower mainstem sampling reach is 16.93% of the substrate composition. The 11-year trend appears to be increasing (Archibald, 2004). Increases in sediment load in this assessment unit are hypothesized to be primarily associated with catastrophic events (e.g. debris torrents and erosion) following severe fire and flood in the 1970's. Several of the small tributaries (e.g. Roaring Creek) in this assessment unit also have higher sediment loads contributing to high percent fines in this assessment unit.

Water Quantity

Flow

Lower Entiat mainstem and tributary flows are highly variable and very responsive to local weather. Surface runoff is rapid on side slopes and moderate on ridges and colluvial swales.

Low flows are a natural occurrence within the subbasin, and naturally limiting to production of some salmonid species. Peak flow timing is assumed to be at or near historic conditions, with current peak flows showing signs of recovery from past fires. However, channel simplification has resulted in faster, more intense runoff in the lower mainstem during storm events and annual snowmelt and has diminished the quality and quantity of current habitat available at given flows.

The 1998 303d list included instream flow as a concern in the lower Entiat River from the town of Ardenvoir (RM 10.0) to the mouth. Irrigation withdrawal is considered to be a relatively minor contribution to lower flows. Average cumulative irrigation water use occurring in the subbasin during August is estimated to be approximately 6-7% (measured at, the Keystone gage, RM 1.4). Additional reach-level effects from irrigation system conveyance inefficiency are not well understood. However, some areas may have an effect of 10 to 13 % from total water withdrawal (water use plus conveyance inefficiency).

Riparian Floodplain

Riparian as well as floodplain function has been substantially changed from historic condition. The construction of roads and homes in the floodplain, filling, diking and channel straightening have reduced or eliminated floodplain connection and function within some areas of the lower Entiat River assessment unit.

Riparian conditions near the confluence with the Columbia River show substantial vigor and contribute positively to stream channel diversity and properly functioning conditions.

However, in many reaches within the Assessment Unit, reduction or total loss of vigorous shrubs in the riparian zone has reduced instream organic input and shade, and contributed to unstable stream banks and associated erosion and has significantly reduced large wood recruitment into the stream channel. Percent canopy cover in the Lower Entiat ranges from 0 to 25 percent.

High road density, a high number of road miles in the riparian corridor, and road maintenance practices have increased sediment delivery to the lower mainstem. All subwatersheds within the Lower Entiat AU have more than 2.7 miles of road per square mile, and 205 miles of road were identified within 300 feet of streams (WNF, 1996).

In-Channel Conditions

Habitat Diversity, Habitat Quantity and Channel Stability

Prior to early settlement of the valley, the Lower Entiat was more sinuous and less entrenched. Because of flood control measures and other developments, channel morphology is now substantially entrenched with high width-to-depth ratios and very little useable (salmonid) habitat complexity and diversity.

The quality and frequency of large pool habitat has been reduced by approximately 85% since the 1930s throughout the Assessment Unit. Current opportunities for large wood recruitment are limited. Substrate in the lower mainstem consists primarily of cobbles (2.5 - 10 inches) and numerous small boulders with some interspersed gravel. The channel is characterized as a series of shallow riffles and glides that transport smaller sized substrate (spawning sized gravels) downstream, rather than depositing it.

Off-channel habitat has been substantially reduced. Tributaries and other areas once contained important off-channel habitat for rearing salmonid, but most are located on developed lands (roads, rip rapped banks, check dams, culverts, etc.) resulting in a loss of this key habitat (WNF 1996; Archibald et al., 2002).

As a result of past actions, the quality and quantity of rearing and holding habitat, off-channel winter rearing habitat, and spawning habitat are considered to be fair to poor throughout most of the Lower Entiat River Assessment Unit.

Fish Passage Barriers

There are no physical passage barriers in the lower mainstem Entiat River. The SSHIAP barriers GIS layer (2003) indicates the following barriers in tributaries (Figure 17):

Mud Creek: there is a culvert at the Entiat River Road that is a partial barrier.

Unnamed Tributary to Mud Creek: there is a culvert with unknown blocking status.

Because tributary temperatures may be elevated somewhat during low flow years, thermal barriers to this habitat may exist during the late summer months.

Elevated water temperatures and lack of habitat complexity (i.e. quality pools) likely have impeded or impaired salmonid migration during the late summer and autumn months.

Ecological Conditions

Pathogens

Pathogens to salmonid species may have increased as a result of hatchery operations and fish species introductions. Ecosystem Diagnosis and Treatment outputs suggest that pathogens may have a low to moderate affect primarily to summer rearing fish. There are no observations or formal studies conducted in the Entiat subbasin to verify these findings.

Predation

Bird and fish predation on salmonid juveniles is likely to have increased due to the overall loss of habitat complexity and associated reduction in hiding cover. Smolt releases from the Entiat National Fish Hatchery likely result in increased avian predation. Reduced in-channel habitat diversity and development of Lake Entiat (Rocky Reach Hydro Project) have increased the abundance of non-native fish species, particularly predators such as the Northern Pikeminnow and bass.

Mammal predation on adult salmonids is likely decreased from the historic reference condition due to displacement of these animals. There are no studies conducted in the Entiat subbasin to verify this finding.

Food

Food resources (macro invertebrate production) for juvenile salmonids have possibly declined from historic reference condition as a result of increased water temperatures and decreased organic inputs and nutrient loads. Reduced salmonid carcasses, reduced riparian / leaf litter and reduced floodplain function have likely lowered nutrient content and benthic macro invertebrate production within the lower Entiat. Results from 2002 WDOE Environmental Assessment Program macroinvertebrate sampling at RM 1.4 show that benthic macroinvertebrate community condition is generally healthy; however, specific characteristics of community condition (only one species of stonefly; relatively large percentage of scrapers) indicate slight degradation. The lack of other stonefly species suggests temperature impairment. Nutrient driven periphyton production may be influencing scraper percentages, and causing occasional pH exceedences.

Harassment

Harassment (or poaching) to late-run Chinook salmon (and other focal species) likely occurs in the lower Entiat River but to an unknown extent. Harassment to these fish is largely a function of lack of hiding cover coupled with recreation use of the river. At this time there is no formal public outreach to educate people of the sensitivity of these fish to disturbance, especially during adult holding and spawning times.

Introduced Species

Steelhead stocking (100,000 per year) occurred until 1999. It is not understood what inter-species or intra-species interactions may have occurred. Salmonid species interactions in the lower river are elevated as a result of juvenile spring chinook out-plantings from the USFWS Entiat NFH (RM 6.0). IHN and C. shasta are pathogens found only in returning adult. There is no information concerning these pathogens in other populations throughout the subbasin. BKD is occasionally a problem in the hatchery when river water is used.

Hatchery operations that segregated domestic from wild stocks may have reduced the genetic fitness of focal species stocks. Although genetic samples from spring chinook and steelhead have been collected, the DNA analysis results are not yet available to help determine the genetic status of stocks.

Environmental/Population Relationships

The lower Entiat River is a crucial migration corridor for the migratory life histories/stages of bull trout, steelhead, spring and summer chinook, and westslope cutthroat trout. Spawning and rearing conditions for salmonids in the lower mainstem Entiat River are considered to be in poor condition.

Pre-spawning and spawning adults find a shortage of deep resting pools and limited gravels suitable for redd formation. During the winter incubation period, water over redds is shallow (less than one foot deep) and cools more quickly, resulting in extended egg incubation periods. Low water temperatures can also cause in the formation of anchor ice that can damage redds, eggs and emerging fry. The tendency for anchor ice to form is increased in reaches with little or no canopy closure due to diminished or no riparian vegetation. In addition to anchor ice, sedimentation and gravel scour are potential sources of pre-emergence mortality. Adult overwintering habitat is lacking.

The combination of natural and artificial channel confinement severely limits the availability of suitable early rearing habitat. Food supply has been reduced and high flow refuge habitat (primarily created via LWD recruitment) is lacking due to the loss of riparian vegetation. Current velocity refugia are primarily associated with riprap and afford little cover from avian or piscine predators. Late rearing habitat also lacks in-channel diversity. The lack of cover and increased summer stream temperatures, particularly as flows drop in the summer and fall, may be limiting salmonid productivity through density dependant mechanisms.

Areas of Special Interest

Maintaining existing riparian habitat and floodplain function is of special interest in the Lower Entiat (MCMCP, 1998; Andonaegui, 1999; UCRTT, 2002). Preserving access to the lower portion of tributaries (primarily Mad, Roaring, Mud and Potato Creeks) for refuge and cover during disturbance events is also important, as natural upstream fish passage barriers (such as high gradient boulder cascades) prevent utilization of many tributaries (e.g. Shamel Creek, Roundy Creek and Tyee Creek). Maintaining and improving good water quality is of special interest.

Limiting Factors

- Loss of channel complexity affects both habitat quality and quantity for fry and juvenile rearing life stages. Loss of large pools below the Mad River confluence has reduced holding habitat for adult Chinook and steelhead.
- Loss of anadromous carcasses and lost riparian has reduced nutrient and food supply. Refugia from high flows and cover from avian or piscine predators is notably lacking. Predation on juvenile salmonids by pikeminnow and bass is likely to be elevated due to Lake Entiat.
- Lost riparian shade likely contributes to elevated high temperatures, which may limit habitat availability. And likely impedes migration during the later summer months.
- Impaired riparian and floodplain conditions contributes to freezing temperatures and anchor ice over much of this area in winter. Low instream flows and low winter stream temperatures, and associated anchor and frazil ice, occasionally displace or kill winter rearing juveniles. Wintertime lows and the formation of anchor ice in the lower mainstem Entiat and Mad Rivers may be a greater limiting factor than summertime highs (USFS WNF 1996).
- Channel segments are highly confined and lack effective floodplain function. Stream energy is not well dissipated, resulting in a poor distribution of water velocities, channel downcutting, bank erosion and loss of spawning gravel recruitment. Channel confinement severely limits the availability of suitable early rearing habitat
- Elevated fine sediment levels contribute to reduced incubation success, reduced benthic-invertebrate production, and reduced over-winter rearing habitat. Sedimentation, gravel scour, and anchor ice heighten pre-emergence mortality, while fish in early rearing stages are left without adequate food or refuge from predators.

Functional Relationship of Lower Entiat River Assessment Unit with the Subbasin

The Lower Entiat is a Category 2 watershed, with no (0) significant subwatersheds. In general, substantial loss of habitat complexity and diversity, and loss of riparian vegetation/floodplain function has occurred in this AU. The lower Entiat does act as a migration corridor for spring chinook salmon, steelhead bull trout, and westslope cutthroat trout. It is also provides spawning and rearing habitat for steelhead and summer chinook salmon (UCRTT, 2002).

Opportunities for restoring full expression of life histories for multiple populations do exist, and the lower mainstem could support additional salmonid production.

4.10.3 Middle Entiat River Assessment Unit

Assessment Unit Description

The Middle Entiat River Assessment Unit extends from the Potato Moraine (RM 16.2) upstream to Entiat Falls (RM 33.8) which is a natural barrier to anadromous passage. Channel morphology in this segment of the mainstem is glacially influenced. Low gradient, meandering, alluvial channels with broad, well-defined floodplains are typical. Tributaries to the mainstem and included in this Assessment Unit are Stormy; Preston, McCrea, Tommy, Fox, Lake, Brennegan, and Pope creeks.

Topography in the Middle Entiat is the result of alpine glaciation, which significantly affected the upper half of the Entiat subbasin. The valley has a characteristic U-shaped appearance, and the Potato Moraine indicates the downstream influence of the glacier on channel geomorphology and bed material (glacial till). Glaciation resulted in steep hanging valleys and a moderately broad floodplain that contains water-stratified silt, sand, gravel and cobbles. The geology of this area makes the landscape more susceptible to natural disturbance events such as mud/debris torrents or scouring. Hill slopes are generally very steep and highly unstable; soils that often consist of pumice or ash exist in many areas.

Precipitation in the Middle Entiat along the mainstem is about 24 inches annually. Average precipitation increases with elevation, with some tributary headwater areas producing in excess of 5 inches each year. Most winter precipitation falls as snow, with some rain occurring at lower elevations. During an average winter, temperatures range from the teens to the 40s; average daily summer temperatures range between 60 and 70 degrees.

Essentially all private ownership occurs along the mainstem Entiat River between RM 16 and the USFS boundary (RM 26); No significant agricultural use occurs within this Assessment Unit. Land use consists of residential/recreation cabins, irrigated pasture/lawn and recreation. The majority of land is publicly owned.

Assessment Unit Condition

Past logging practices, fire suppression activities, roading, private development and past over-grazing have been the prime causes of degradation in the Middle Entiat (Archibald et al., 2002; 2003). The upper area of the Assessment Unit maintains many attributes similar to the historic reference condition. Conditions in the lower portion of the AU have been altered and are considered to range from fair to good.

Within this Assessment Unit is the "Stillwater" area. The Entiat River within this area has high sinuosity, fair to very good habitat conditions for anadromous production. Reaches within this area provide for the primary spawning and rearing of chinook and steelhead within the subbasin. This area will also be key to potential coho salmon re-introduction efforts.

Water Quality

Water quality in the Middle Entiat is generally at or near pristine condition. The middle mainstem Entiat River has never been placed on the WDOE 303(d) list of water quality impaired streams. Tributaries and the portion of the mainstem below the USFS boundary (RM 26) are classified as Class A (excellent) according to state water quality standards; from RM 26 to Entiat Falls (RM33.8), streams are classified as Class AA (extraordinary).

It is likely that stream temperatures within the area from Preston Creek to the Forest Boundary will regularly exceed State standards for Class AA rivers (61°F) during most summers, based on natural conditions alone (Archibald et al., 2003). From the USFS boundary at RM 26 downstream to RM 18, the river flows through an increasingly wider U-shaped valley where it exhibits increased sinuosity and a lower gradient compared to all other areas of the Entiat River. In this area (Stillwater reach) where stream temperatures would be naturally expected to increase as well, a temperature moderating influence was observed in 1999-2002. The moderating zone lies between RM 21 and RM 16, and is most likely related to the depth of alluvial aquifer / glacial till deposits here.

Contaminants

Herbicides may enter the water system and degrade water quality. Potential fecal coli form inputs from increasing development and associated septic systems and livestock use are the primary concern with respect to future effects on water quality.

Fine Sediment

The effect of human activities on fine sediment in the Stillwater and in the upper portion of the AU has yet to be determined; however, riparian clearing and roading has likely resulted in bank erosion and increased sediment delivery in the Stormy and Preston Creek area. Altered ground cover as a result of moderate to heavy historic sheep grazing and timber harvest activities (including road building) dating back to the turn of the century, has not been adequate in some areas to protect the soil surface from erosive forces.

Sediment (mean percent fines <1.0mm) range from approximately 6% in upper (higher gradient) stream reaches to approximately 15% in lower (lower gradient) reaches. Sediment input is primarily from recent intense fires, although extensive roading in some areas contributes sediment to streams. The 11-year trend (based on data from three fine sediment sampling reaches) appears to be decreasing sediment inputs (Archibald, 2003).

Water Quantity

Flow

The Middle Entiat is subject to high runoff from rapid melt or rain-on-snow events. Major precipitation events associated with spring runoff when snowmelt was rapid have led to flash floods or mud/debris flows (Archibald et al., 2002; Archibald et al., 2003). Response is characterized by rapid sediment transport in high gradient reaches.

Currently, hydrologic function in the Middle Entiat is near baseline/historic reference conditions. Past grazing activities may have contributed to the lowering of the water table in historically wet meadows. Other alterations may exist due to past high intensity fires, although these conditions are considered to be within the range of natural variation.

The Washington Department of Ecology 1998 303d list indicated that low flows from RM 10 (Ardenvoir) to RM 27.7 are natural, and little water use occurs in the Middle Entiat AU (CCCD, 2004). Current water use is primarily associated with residences, lawn/pasture irrigation and recreational campgrounds.

Riparian and Floodplain Condition

Riparian condition and floodplain function is considered to be in fair to excellent condition. Fair conditions exist in localized areas (20-30% of AU stream area) where fire, riparian clearing / development, channel simplification (dikes to prevent channel migration) and grazing have resulted in lost side channel connectivity, lost recruitment of large wood into the stream channel, accelerated channel migration and erosion. Past logging and roading has affected tributary riparian condition, particularly in Preston and Brennegan creeks. The Stillwater area remains functionally intact, is generally in good condition, although localized areas have been altered.

Roads present in the riparian area near the mainstem Entiat River and some tributaries are a major cause of riparian fragmentation. The USFS identified 43 miles of road within 300 feet of stream channels (WNF 1996; CCCD, 2004). Road density in some areas is second highest on the Entiat Ranger District (>2.4 mi/mi^2). The majority of the roads were built after the 1970 Entiat Fires to support salvage logging sales and attendant jammer-logging road building (Archibald et al., 2003). Road densities in Preston and Brennegan creeks (most are contour roads that cross the creeks) are as high as 6mi/sq.mi. Riparian clearing and roading has resulted in a loss of side channel habitats, backwater pools and stream / riparian interface and a loss of off-channel refugia for juvenile salmonids. Where off channel habitat does exist, it is in stable condition.

In-Channel Condition

Habitat Diversity, Habitat Quantity and Channel Stability

Stream and fish habitat conditions range from fair to good. General channel features, such as sinuosity and width/depth ratios, exhibit near normal features. Localized bank erosion, and loss of habitat diversity and channel complexity is apparent due to stream channel clearing and development in floodplain/ riparian areas.

The Stillwater section from Potato moraine (RM 16.1) to McCrea Creek (~RM 25) retains a more natural channel with much higher sinuosity, typical bankfull width and width-to-depth ratios, numerous log jams, undercut banks and deep pools. Spawning-sized gravels are abundant here.

Large woody debris is significantly lacking within areas of the AU due to past activities mentioned above. Box Canyon also restricts the through-movement of large wood, thus limiting recruitment. The trend for large wood in the stream is increasing due to blow-down of dead trees from past fires. Current large pool frequency and quality are good in the Stillwater, averaging approximately 35% of the habitat area. Pool spacing is at every 5 to 7 bankfull channel widths (close to the expected geomorphic potential), although still below USFS standards.

Streambank condition is generally good from the Potato moraine to Entiat Falls (Archibald et al., 2003). Overall human disturbance is minimal with only the Entiat River Road (to Cottonwood Trailhead) and the Entiat trail system providing access to the river. However, in lower gradient areas there is stream bank loss due to lateral channel migration, which has been accelerated by bank clearing and development in floodplain/riparian areas. The reaches of the upper mid-Entiat River are >90 percent stable.

Fish Passage Barriers

Fish passage throughout the mainstem of this Assessment Unit is good for anadromous fish, bull trout and cutthroat trout (Archibald et al., 2002) and at the historic reference condition (Figure 17). Passage in tributary streams is hindered or blocked, primarily for juvenile life stages, by natural and man-made barriers. The amount of habitat upstream of tributary culvert barriers is limited. The SSHIAP inventory has identified 18 fish passage barriers in the tributary streams from the Potato Moraine to Entiat Falls.

Ecological Conditions

Food

Salmonid populations have been significantly reduced in this Assessment Unit from the historic reference condition. As a result, carcass availability and nutrient supply for macroinvertebrate production has been reduced, thereby reducing the available food source for all native fish species in this area. Loss of side channel habitats, backwater pools, stream/riparian interface, and beaver in lower gradient areas has also likely diminished nutrient input from historic reference conditions.

Harassment

Harassment and potentially poaching on chinook salmon and adult fluvial bull trout likely occurs in the Middle Entiat Assessment Unit but to an unknown extent. Harassment to these fish is largely a function of lack of hiding cover coupled with recreation use of the river. At this time there is no formal public outreach to educate people of the sensitivity of these fish to disturbance, especially during adult holding and spawning times.

Introduced Species

Hatchery operations and past stocking may have reduced the genetic fitness of focal species stocks and resulted in competition for habitat. The Entiat National Fish Hatchery raises and releases spring chinook into the Entiat watershed (CCCD, 2004). There is the potential for genetic integration between hatchery and naturally spawning spring chinook. There is also the potential for increased competition for rearing habitat between hatchery and naturally spawned fish.

Although genetic samples from spring Chinook and steelhead have been collected, DNA analysis results are not yet available to help determine the genetic status of stocks. Introduction of non-native eastern brook trout has resulted in a self-sustaining population primarily above Entiat Falls. Brook trout are occasionally found downstream (within 2-miles) of Entiat Falls (Andonaegui, 1999). Interactions between brook trout and focal species have not been evaluated.

Environmental/Population Relationships

The Middle Entiat AU provides critical spawning and rearing habitat for anadromous salmonids. Of the areas within the subbasin affected by land use practices and flood control projects, the Middle Entiat has been least modified. Suitable spawning and rearing habitats are present, although certain habitat conditions have been diminished in localized areas due to past timber/fire/roading activities, and development. These activities have likely reduced potential carrying capacity for salmonid production.

In general, spawning and rearing conditions for salmon and steelhead are considered to be good to excellent above the moraine, with adequate cover, favorable velocities and high flow refuge habitat (WNF 1996; CCCD, 2004). Primary summer Chinook spawning is found between the moraine (RM 16.1) and RM 18.7. Spring Chinook tend to spawn in the seven mile “index area” between RM 21 and RM 28; early rearing also occurs in this more pristine area. Steelhead spawning occurs in the mainstem between Stormy Creek (RM 18) and Fox Creek (RM 28).

From the McCrea confluence upstream to Entiat Falls, fish habitat in the mainstem Entiat has been modified from the condition found in 1930’s surveys, yet the amount of pool habitat and large woody debris within this reach is good (CCCD, 2004). Primarily bull trout and other resident fish utilize the fair to excellent quality habitat in this zone; spring chinook and summer steelhead use is limited to the lower reaches due to natural barriers (CCCD, 2004). The trend in habitat condition is variable and uncertain, and some channel sections have been locally impacted by timber harvest in tributaries, and by road crossings.

Areas of Special Interest

Maintaining intact areas of mainstem and side channel riparian habitat in the Stillwater Reach between the moraine and Fox Creek is important to maintain natural chinook and steelhead production in the Entiat subbasin (MCMCP, 1998; Andonaegui, 1999). Maintain increasing trend in LWD recruitment and pool formation below Fox Creek will enhance habitat diversity and carrying capacity.

Maintaining existing fluvial processes and floodplain connectivity/habitats from the Potato Moraine to Entiat Falls is also of interest (UCRTT, 2004). Fluvial processes are now good within this reach, but they are at risk from future development pressure in bottomlands (UCRTT, 2004).

Limiting Factors

- Past stream clean-outs and salvage logging activities after major fire events have affected stream channel complexity (UCRTT, 2004) and habitat diversity in some reaches.
- The loss of large wood and key side channel habitat (particularly in low gradient sections) likely limits juvenile/rearing salmonid productivity
- Surface erosion and sediment delivery hazard is high in many areas. Highly erosive uplands deliver sediment to streams, particularly Fox, McCree, Brenegan, Preston, and Mud creeks, and the mainstem Entiat between Fox and Stormy creeks (UCRTT, 2002)
- Harassment or poaching of spawning salmonids may occur at campgrounds and other access points (UCRTT, 2004).
- Lack of nutrients, particularly the loss of large numbers of salmon carcasses, has resulted in a loss in primary biologic productivity and reduced food resources for salmonids.

Functional Relationship of Middle Entiat within the Entiat Subbasin

The Middle Entiat is a Category 1 watershed, with two (2) significant subwatersheds, including the Upper Mid-Entiat and the Lower Mid-Entiat. The Middle Entiat is critical habitat for Chinook salmon, steelhead, and bull trout production and is designated as a Key Watershed in the Northwest Forest Plan (UCRTT, 2004).

4.10.4 Upper Entiat River Assessment Unit

Assessment Unit Description

The Upper Entiat River Assessment Unit (Upper Entiat) extends from Entiat Falls (RM 33.8) to the headwater area of the subbasin. This AU contains strongly glaciated land types with high subsurface water storage capacity. The primary tributary to the mainstem is the North Fork Entiat River. All nine of the major lakes of the Entiat subbasin are found in the Upper Entiat (Andonaegui, 1999).

Precipitation averages 34-36” annually in the mainstem area of the Upper Entiat below the North Fork. Upstream from here, precipitation levels continue to increase with elevation. Some tributary headwaters areas receive an annual average of 54-56”, the highest of all levels found within the subbasin. Almost all winter precipitation falls as snow.

Soils in the Upper Entiat have high porosity, low surface moisture retention and are easily eroded. Subsurface water, seeps and springs contribute to weathering of bedrock, soil creep, and mass wasting in localized areas of tributary watersheds (Archibald et al., 2003). Avalanche chutes and debris tracks are associated with low order channels. Glacial till deposits intercept runoff from upper slopes and seepage along lower slopes, and are important in regulating stream flow and temperature (Archibald et al., 2003).

All land within the Upper Entiat is managed by the US Forest Service. There are seven developed campgrounds and many recreational trails. Over the past decade, recreation on the Entiat Ranger District has increased steadily, with weekends typically running over 100 percent capacity and weekday use during July and August at 50 to 60% (CCCD, 2004).

Assessment Unit Condition

General watershed conditions in the Upper Entiat are good to excellent. Aquatic habitat is stable and assumed to be similar to historic conditions, and stream channels are mostly within wilderness or unroaded areas. Management effects have been relatively minor, and the natural occurrence of fire is the primary disturbance mechanism. Historic concentrated sheep grazing has affected conditions in localized areas, although dispersed recreation, localized grazing, and trail impacts are current management areas of interest (CCCD, 2004).

Resident fish, particularly rainbow and cutthroat trout, dominate the Upper Entiat (USFS, 1996; Andonaegui, 1999). Non-native eastern brook trout and hatchery reared cutthroat and rainbow are also present. Anadromous fish are absent from this AU due to the natural barrier at Entiat Falls.

Water Quality

Water quality in the Upper Entiat is essentially in pristine condition (Mullan et al., 1992). Coarse and fine sediment are recruited by naturally occurring debris flows, and fines are transported through the Upper Entiat with minimal deposition (Andonaegui, 1999; CCCD, 2004).

Water Quantity

The current flow regime is at or near the historic reference condition (USFS, 1996; Andonaegui, 1999), although historic beaver trapping may have diminished water storage capacity and altered flow regimes to a minor degree. Percolation and storage of ground water by deep glacial till deposits and abundant seeps, springs and tributaries moderate stream temperatures and provide thermal refugia (Archibald et al., 2003).

Riparian Floodplain

Riparian and floodplain attributes are stable and considered to be in good to excellent condition and are at or near the historic reference condition. Riparian reserves are providing adequate shade, large woody debris recruitment, habitat protection, and connectivity in all subwatersheds of the Upper Entiat Assessment Unit.

Road densities in the Upper Entiat are low. A total of 5.9 miles of road are found in riparian areas (0.05 miles of road/square mile) (Archibald et al., 2003). Overall road density is 0.4 miles/square mile, and all subwatersheds have less than one mile of road per square mile. The highest trail densities (162.7 miles of trails) are found within the

Upper Entiat (Andonaegui, 1999). Some localized compaction and disturbance of riparian vegetation is noted due primarily to trails and recreation, although these are minor at the subbasin scale.

In-Channel Conditions

Habitat Diversity, Habitat Quantity and Channel Stability

In channel habitat conditions in the Upper Entiat are considered to be good to excellent, and near historic reference condition due to minimal human disturbance (USFS, 1996; Andonaegui, 1999). Only the Entiat River Road (to Cottonwood Trailhead) and the Entiat trail system provide access to the mainstem Entiat River.

Habitat diversity is provided by side channels, boulders and large woody debris. Streams substrate is primarily cobble/gravel. The number of large pools is similar to or higher than the number observed during 1930's stream surveys. Overall, channels and stream banks are in good condition (Archibald et al., 2003), as most are within wilderness or unroaded areas.

Some channel modifications from historic have likely occurred as a result of historic actions including beaver trapping and concentrated sheep grazing. Erosion/degradation of bank stability as a result of recreational use/trails is occurring only in localized areas (Andonaegui, 1999).

Fish Passage Barriers

There are no man-made barriers to passage within the Upper Entiat (Figure 17). Entiat Falls (RM 33.8) located at the lower end of this AU acts as natural barrier to the upstream migration of all anadromous species (Archibald et al., 2003; Andonaegui, 1999).

Ecological Conditions

Introduced Species

Many ecologic attributes remain intact from the historic reference condition. However, the Upper Entiat has been affected by extensive stocking of hatchery reared rainbow and westslope cutthroat trout in streams and especially the high lakes, and the introduction of eastern brook trout above Entiat Falls.

Eastern brook trout are no longer stocked, and all government stocking of cutthroat and rainbow trout ceased in1996 (Andonaegui, 1999; Archibald et al., 2003). A self-sustaining population of brook trout now exists in this AU.

Introductions of rainbow and hatchery reared westslope cutthroat trout into habitats previously occupied only by westslope cutthroat trout have resulted in widespread introgression, with many cases of westslope/redband hybrids identified as westslope cutthroat trout. The main concerns regarding the status of resident species are: genetic introgression, especially with introduced rainbow trout; depressed and fragmented populations; and the loss of migratory life histories (Archibald et al., 2003).

Environmental/Population Relationships

The Upper Entiat has been minimally affected by past activities, and fish habitat condition is stable and assumed to be similar to the historic condition. Although anadromous species access to habitat is blocked by Entiat Falls, this AU provides good to excellent habitat for resident fish species.

Areas of Special Interest

Protection of the existing hydrologic regime, riparian condition, floodplain function, aquatic habitat and channel condition is of special interest.

Limiting Factors

No factors that limit the production of endemic fish species in the Upper Entiat have been identified. The productivity of cutthroat trout may be limited by genetic introgression and the presence of brook trout.

Functional Relationship of Upper Entiat Assessment Unit with the Subbasin

The Upper Entiat provides good/excellent spawning and rearing habitat for resident trout species. Due to the quality of existing habitat, the goal is maintaining conditions in this portion of the subbasin, and minimizing recreation impacts. The elimination of eastern brook trout would improve conditions for endemic resident fish.

4.10.5 Mad River Assessment Unit

Assessment Unit Description

The Mad River Assessment Unit, consisting of the entire mainstem river and its tributaries drains approximately 58,300 acres. The Mad River originates from a glaciated basin near the crest of Tyee Ridge and flows southeasterly through a U-shaped valley for nearly 24 miles. It joins the west bank of the Entiat River at RM 10.5, just upstream from the town of Ardenvoir. Notable tributaries to the mainstem Mad River include Cougar, Hornet and Tillicum Creeks. Several alpine lakes, including Mad Lake (source of the Mad River) are also found within the Mad AU.

Annual precipitation within the Mad River watershed ranges from 20 inches per year near the confluence with the Entiat River, to 60 inches per year in the headwaters and at higher elevations. The majority of the annual precipitation falls in the form of snow, during late fall and winter (October to March). Percolation and storage of ground water by deep glacial till deposits and abundant seeps, springs and tributaries moderate stream temperatures and provide thermal refugia within the Mad River above Cougar Creek.

Approximately 95% of the Mad AU is publicly owned. An extensive 85-mile system of single-track multiple-use trails exists and provides for a wide variety of recreational activities. Lands privately owned by individual landowners constitute the remaining 5% of the total Mad watershed area (Archibald et al., 2003a). Private development/land use is limited to the area along the lower 2-miles of the mainstem Mad River, and lower Tillicum Creek.

Assessment Unit Condition

The primary natural disturbance process within the Mad River watershed is forest fire.

Current watershed attributes are considered to be in generally good to excellent condition. However, past commercial mining and packer operations in the Maverick Saddle area, unregulated sheep grazing, subsequent grazing allotments, wildfire, logging, road construction and development have degraded some habitat attributes to varying degrees.

Water Quality

The Mad River has no Clean Water Act 303(d) designated reaches. Data from sampling conducted at the Mill Camp Bridge (RM 0.25) from May 1995 through October 1996 showed good pH, dissolved oxygen, fecal coli form, nitrate/nitrite, and turbidity levels. Occasional nutrients inputs are associated with development/land use in the Ardenvoir area occur along the lower mile of the Mad River and around its confluence with the Entiat River (Archibald et al., 2003a), although these are considered to be minor.

Temperature

Maximum water temperatures often exceed 61°F in the lower Mad River (CCCD, 2004) during summer high temperatures, although water temperatures are believed to be at or near the historic reference condition. Essentially no direct management of riparian and valley bottom vegetation has occurred from RM 4 to the headwaters (nearly 20 miles). The effects of past wildfires in riparian areas may exacerbate natural high temperature conditions during low flow years. Cooler temperatures are noted in the upper watershed due to ground water input in the Cougar to Jimmy Creek reach. These areas provide for the primary bull trout spawning within the Entiat subbasin.

Fine Sediment

It is likely that sediment yield in the Mad River is at or near the historic reference condition. Eleven years of fine sediment data collected between the Mill Camp Bridge (RM 0.25) and Pine Flat campground (RM 4.0) indicate that sediment loads in the lower Mad River average 16.9% composition fines ($\leq$1.0 mm). Measurements indicate sediment rates are moderately variable within a range of 12 to 19%, but in a long-term stable and a decreasing trend. County road maintenance activities (side-casting of material into the lower Mad River approximately ¾ mile upstream of the mouth) likely result in increased sediment input to the stream.

Water Quantity

Flow conditions in the Mad River Assessment Unit are likely near the historic reference condition, relatively stable and functioning appropriately (Archibald et al., 2003a). Streamflow data collected from 1991-1995 at the USGS gage (RM 0.2) in Ardenvoir show average annual streamflow is 60cfs. Base flows and flow timing appear unchanged from pre-fire conditions. Average annual peak flows recorded during the same years from mid-May to early June ranged from 300 to 400 cfs, with average annual base flows recorded September to January about 20 to 40 cfs. In the lower Mad River, surface runoff is rapid, water storage is reduced, flows are poorly regulated and can be flashy depending on precipitation and runoff events.

Water use occurring in the lower Mad River is insignificant in comparison to total subbasin use. There are 4 surface water certificates and permits worth a potential total diversion of 70.2 cfs; surface and ground water claims total a potential withdrawal of 0.3cfs (CCCD, 2004). It has been advised that new water diversions from the Mad River during May and June should be limited until further study demonstrates that additional water could be withdrawn without adversely affecting current channel conditions or levels of fish production (CCCD, 2004).

Riparian Floodplain

Riparian and Floodplain Condition

Floodplain function is generally in fair to good condition in this Assessment Unit.

The connectivity of the floodplain from the mouth of Mad River to Pine Flats Campground (RM 4) has been greatly reduced by orchards, the town of Ardenvoir, County Road #119, and Forest Service Road #5700.

Riparian attributes are generally in fair to good condition in this Assessment Unit. In the upper mainstem and headwaters areas (Young Creek to Blue Creek) riparian condition is good, with greater than 90% of riparian reserves intact. Upper Mad riparian areas provide adequate shade, large woody debris recruitment and subwatershed connectivity, and provide refugia for steelhead, bull trout and cutthroat trout. In the area from Pine Flats Campground (RM 4) upstream to Young Creek, greater than 65% of the riparian area was burned during the 1994 fire. Riparian conditions are fair, with post-fire recovery proceeding rapidly and according to natural processes.

In the lower mainstem Mad from the mouth to Pine Flats Campground (~RM 4) road encroachment, agriculture, and development have resulted in a loss of loss of riparian connectivity and function. Effects of management activities are considered to be relatively minor at the watershed scale, although this lower area provides for chinook spawning and approximately 50% of steelhead spawning habitat.

The majority of roads within the Mad Assessment Unit are found within the lower Mad River and the Tillicum Creek drainage, a legacy from the days of jammer logging and fire salvage in the 1970s. High road densities in Tillicum Creek may contribute to modest alteration of flow timing and runoff patterns. The highest riparian road density (>2.4 mi/mi^2) is found in the lower and middle Mad River, where spring chinook and steelhead are known to spawn. The lower 2-3 miles of the mainstem Mad River is confined by the County road. Lower mainstem habitat conditions for spring Chinook and steelhead are considered poor, although refugia conditions are fair.

In-Channel Conditions

Habitat Diversity, Habitat Quantity and Channel Stability

In general, stream channel conditions and function are in good condition from Pine Flats Campground upstream to the Mad River headwaters. Human disturbance is minimal with only the Mad River trail providing access to the river. Habitat conditions have been greatly modified in the lower Mad River from the mouth to Pine Flats Campground (RM 4), and stream channel conditions and function are in fair to poor condition. In the 1995/97 survey of the Mad River, the mouth to Pine Flats Campground had an average bankfull width/depth ratio within the expected range of its channel type. However, this area has been developed, channelized and artificially constrained.

Embeddedness levels are in good condition upstream from Pine Flats Campground (Archibald et al., 2003a). From Pine Flats downstream to the mouth, artificial confinement of the channel near the town of Ardenvoir, wood removal following the 1970 Gold Ridge fire, and higher percentages of larger substrate have reduced the ability of the river to retain adequate amounts of gravel and cobble-sized substrate, thus adversely affecting spawning and rearing habitat availability for Chinook and steelhead.

The majority of the Mad River and its tributaries are in good condition for large woody debris (Archibald et al., 2003a). Historically, the mouth of Mad River to Pine Flats Campground was thought to be highly complex with abundant LWD. However, existing large wood in the stream channel is reduced. Counts from 1990 and 1995-1997 stream surveys showed only 10 pieces/mile in the lower Mad River.

Most Mad River reaches have experienced a considerable increase (195%) in pool habitat from conditions documented during 1930's (WNF, 1996). The low numbers of pools noted in the 1930's survey is most likely due to the Mad River Gorge Fire of 1888 which intensively burned potential and downed pool-forming LWD. Post 1994 Tyee fire surveys conducted in 1995-1997 show that large pool frequency and condition upstream of Pine Flats Campground is in fair to good condition, although a decrease in pool frequency from 1990 in the Pine Flats to Young Creek area was noted.

Off-channel areas from Pine Flats Campground to Mad Lake are hydrologically connected to main channels and are in good condition (Archibald et al., 2003a). The occurrence of off channel habitat is tightly linked to natural channel confinement by bedrock (Archibald et al., 2003a). In the lower mainstem, floodplain developments have reduced off-channel habitat. Side channels made up only 1% of the wetted habitat area in both the 1990 and 1995/97 stream surveys.

Throughout most of the Mad River watershed, streambank erosion and mass wasting is mainly due to natural bank-cutting at the apex of channel bends. General streambank condition from Pine Flats Campground upstream is in good condition (Archibald et al., 2003a). Streambank conditions in the area from the mouth to Pine Flats Campground are fair. Active bank erosion of the lower Mad River is due mainly to human activity at the town of Ardenvoir, and the close proximity of roads.

Fish Passage Barriers

Historically, fish passage was affected by migration barriers. The last remaining man-made passage barrier within the Mad River watershed, an irrigation diversion dam at Mad River mile 0.26, was reconstructed in November 1994 to be fully passable at all flows for steelhead, spring chinook, bull trout and cutthroat trout (Archibald et al., 2003a). In 2001 and again in 2002 a "swimming pool" was created (and then dismantled) in the lower

Mad River near Mill Camp. Currently, no man-made passage barriers to fish are present on the mainstem Mad River (Archibald et al., 2003a). In Tillicum Creek near RM 2, two potential barriers to steelhead passage exist within ¼ mile of one another. A natural barrier exists slightly upstream of the upper barrier (Figure 17).

The SSHIAP (WDFW, 2003) Barriers GIS layer shows the following natural fish passage issues:

- Cougar Creek has a natural falls (~RM 2.5) that is a complete fish passage barrier.
- Mad River (upstream from Jimmy Creek) has a complete barrier due to cascades, gradient or velocity.
- Mad River (downstream from Alma Creek) has a log jam that is a partial fish passage barrier.
- Tillicum Creek has a natural falls (RM 3.8) that is a complete fish passage barrier.

Ecological Conditions

Many ecologic attributes remain intact from the historic reference condition. Cutthroat trout are known to occur in the headwaters and upper Mad River, its major tributaries and Mad Lake The headwaters of the Mad River are considered to have genetically "pure" and "good" phenotypic representatives of westslope cutthroat trout (Archibald et al., 2003b).. The confluence of Cougar Creek and Mad River is known to be a critical area within the subbasin for bull trout spawning and rearing.

Food

A lack of anadromous salmonid carcasses and nutrient inputs is noted, although 1992 macroinvertebrate sampling data showed good health of the aquatic community. Macroinvertebrate species diversity and abundance are considered indicative of the good health of the aquatic community and of general good water quality for the Mad River (Archibald et al., 2003a).

Pathogens

Steelhead smolts were out-planted (until 1999) in the Mad River; impacts to fish health resulting from pathogens is unknown.

Introduced Species

In those areas of the watershed accessible to anadromous fish, the issue of non-native fish versus native fish is complicated because it is accepted that the native salmon and steelhead stocks (coho, summer steelhead and spring chinook) present prior to European settlement were eliminated (by barriers to passage) from the Entiat by the 1930's. Following the 1930's, the Grand Coulee Maintenance Project began the stocking of salmonids which, in the Entiat, included sockeye, a species not native to the Entiat, coho, steelhead, and chinook stocks trapped at Rock Island Dam and/or introduced from the lower Columbia River. Subbasin-wide, the genetic makeup of westslope cutthroat trout is considered to be intact, although extensive introductions from populations reared out of the subbasin may have affected this species (Archibald et al., 2003a). It is not understood to what degree hatchery steelhead out-plants interact or spawn with cutthroat trout.

Environmental/Population Relationships

The Entiat and Mad Rivers currently support runs of steelhead, bull trout, and spring and late-run chinook salmon. Coho salmon were once present in the Entiat watershed (Mullan et al., 1992; CCCD, 2004), but are now considered extinct. Sockeye salmon were also introduced into the Entiat River at one point. Notably, both coho and sockeye have recently been found utilizing the Entiat River (CCCD, 2004). The Entiat River and the Mad River interact by providing connectivity and habitat for different life stages, i.e. the majority of bull trout spawning occurs in the Mad River but the Entiat River provides holding and rearing habitat and connectivity to other watersheds and subbasins (Archibald et al., 2003a).

Areas of Special Interest

Protection of existing riparian bottomlands in the lower Mad River (MCMCP, 1998; Andonaegui, 1999; UCRTT, 2002), aquatic habitat, fluvial processes, and floodplain function are of special interest in the Mad River (UCRTT, 2002).

Limiting Factors

- Wintertime low temperatures and the formation of anchor ice in the lower Mad River may limit salmonid production (WNF, 1996). Anchor ice formations associated with loss of riparian cover and changes in channel morphology are a limiting factor (UCRTT, 2002).
- A lack of overwintering juvenile rearing habitat, especially in the lower watershed limits productivity and distribution of steelhead and chinook (Andonaegui 1999; CCCD, 2004).
- Sediments may limit productivity due to un-forested and erosive uplands (UCRTT, 2004).
- River access may allow harassment or poaching of bull trout (UCRTT, 2004) and other species.
- The road constricts the channel increasing flow velocities and limiting habitat diversity on mainstem from Pine Flat Campground downstream to mouth (Archibald et al., 2003).

Functional Relationship of Mad River within the Entiat Subbasin

The Mad River is a stronghold for bull trout and provides a migration corridor, spawning, and rearing habitat for spring chinook, steelhead, bull trout, and cutthroat trout. The Mad River AU has been designated as a Category 1 watershed, with three (3) significant subwatersheds, including the Upper Mad River, Middle Mad River, and Lower Mad River (UCRTT, 2004). It serves as critical refugia and habitat for maintaining and recovering at-risk-stocks of anadromous salmonids and resident fish species.

5 Inventory

5.1 Introduction, Purpose, and Scope

The inventory of the Entat subbasin summarizes the fish and wildlife protection, restoration, and artificial production projects and programs. The Inventory also identifies management programs and projects that target fish and wildlife or otherwise provide substantial benefit to fish and wildlife. The inventory includes programs and projects extant or the past five years and where possible, activities that are scheduled to be implemented within the very near future.

The inventory of programs and projects helps demonstrate current management directions, existing and imminent protections, and current strategies. However, the Council's "Technical Guide for Subbasin Planners" (2002), states that the inventory will have its greatest value when it is reviewed in conjunction with the limiting factors resulting from the assessment. This analysis helps to identify gaps between ongoing management efforts and those efforts needed to realize the vision of the subbasin plan.

A comparison of past actions with limiting factors should help assess the efficacy of current actions, indicate the areas of project gaps and guide management decisions. Please refer to the electronic reference library (NPCC ftp site) for an inventory of programmatic activities within this subbasin.

5.2 Inventory of Watershed Restoration and Habitat Improvement

This inventory summarizes some of the watershed restoration and habitat improvement projects and initiatives conducted on both public and private lands in the Entiat and Mad River watersheds over the last several years. It was created using an unpublished list of projects completed on National Forest System Lands between 1992 and 2003, a list of BPA projects from the Columbia Basin Fish and Wildlife Authority's website, a draft programatic inventory of the Columbia Cascades Province completed by Golder Associates, and information regarding any additional restoration / protection efforts that have occurred on private/non-Forest System lands within the subbasin. This appendix will be updated in subsequent versions of this document.

Burned Area Emergency Rehabilitation

A significant amount of rehabilitation work has occurred in the subbasin in association with large scale fires. The following reports contain details of the Burned Area Emergency Rehabilitation measures implemented following the Dinkelman and Tyee disturbance events:

- Burned Area Emergency Rehabilitation - Final Accomplishment Report for the 1988 Dinkelman Canyon Fire, 1989
- Burned Area Emergency Rehabilitation - Final Accomplishment Report for the 1994 Chelan County Fires, 1995
- Other Restoration-Related Activities, broken down by Assessment Unit

Other restoration projects and initiatives implemented since 1992 includes the following:

NOTE: Projects with a scope that extended over more than one Assessment Unit are included in this list in italic text. These projects are included in the inventory for each of the applicible Assessment Units.

Lower Entiat Assessment Unit

Mouth (RM 0) to Potato Moraine (RM 16.2)

1992

- Potato Creek Road Decommissioning: Involved decommissioning of a riparian section on the main road in upper Potato Creek (1.6 miles) that had been replaced by a new hillslope route; Treatment included ripping, drain dip installation and revegetation.
- Reconstruction of the Windy Creek Water Chance: The first of a series of projects targeted at replacing temporary waterchance structures with more natural and stable log weirs.

1993

- Mud-Potato Area Road Rehabilitation: Involved rehab work on the dense road network in upper Mud and Potato Creeks; Treatments included drainage improvements (drain dips, ditch relief culverts) and spot surfacing on open roads, as well as road closures (12 miles) and decommissioning (28 miles), with revegetation. ($17,000)
- Lower Potato Creek Road Rehab: Involved drainage improvements on the North Fork Potato Creek Road and a newly relocated section of the main Potato Creek Road by the Forest Road Crew; Treatments included cut slope stabilization, drain dip installation and armoring and spot surfacing. (~$25,000)
- Water Chance Reconstruction: Rehabilitated 3 sites associated with road crossings in Mud and North Fork Potato Creeks as described above for the Windy Creek site in 1992.

1994

- Mills-Roaring Creek Road Rehab: Involved road rehab work in the Mills/Dinkelman/Roaring Creeks area; Treatments included drainage improvements (drain dips, culvert improvement/installation), road reshaping, crossing improvements, road closures and revegetation; This work was completed under three separate contracts prior to the start of the Tyee Fire. ($29,000; Mills Creek, Roaring Creek and Old Camp Road contracts)
- Roaring Creek Riparian Clean-Up: A community-based improvement project targeted at improving conditions in and public awareness of Roaring Creek and its riparian area; Treatments on various ownerships included removal of four abandoned automobiles and other litter, tree planting and closure of user-built ORV trails in the riparian area.

- Mud-Potato Creek Road Rehab: This project was planned and contracted prior to the Tyee Fire. Some of the planned work was either completed or modified by Tyee Fire Emergency Burned Area road rehab work. The project was redesigned and completed in 1995 and included fill slope stabilization, drain dip and culvert installation, spot surfacing and revegetation. ($65,000)

1995

- Potato-Stormy "Early" Road Rehab: Involved drainage improvement (drain dip/culvert installation), stream crossing/fill slope stabilization, temporary road relocation, spot surfacing and revegetation on roads in the lower Potato Creek drainage, in response to damage from spring runoff. ($30,000)
- Bear-Potato Early Road Rehab: Involved continuation of Emergency Burned Area Treatments on road in the Mud and Potato Creek drainages; Treatments included drainage improvement (drain dips, culvert installation), spot surfacing, fill slope stabilization and revegetation. ($49,000)
- Tyee Fire Culvert Replacement: Involved the installation of four large, concrete box culverts at four stream crossings in lower Mud and Potato Creeks by the Forest Road Crew. ($72,000)
- Tyee Fire Late Road Rehab: Involved drainage improvement, surfacing and revegetation on priority, problem road segments within the fire area that were not treated in any previous contracts; Treatments included drainage improvement (dips, culvert improvement), prism reshaping, spot surfacing, slash filter windrow placement, road decommissioning (riparian road sections in N Fk Mud and Potato Creeks) and revegtation. ($36,000)
- North Fork Drainage Improvement: Involved installation of three new culverts on 5380/5390 roads in upper North Fork Potato Creek by the Forest Road Crew. ($4,000)

1996

- Early Entiat Road Rehab: Involved the installation of drain dips, spot surfacing and fill slope stabilization on lower Mud and Potato Creeks in response to spring runoff within the Tyee Fire Area. ($35,000)
- Mud-Potato Creek Culverts: Involved installation of several stream crossing structures on road sections in lower Mud and Potato Creeks. Treatments included spot surfacing and armoring of fill slopes. ($44,000)

1997

- Mills Canyon/Old Camp Road Rehab: Involved drainage improvement work (primarily drain dip installation/reconstruction and prism reshaping) on the Mills Canyon and Old Camp Roads. ($49,000)
- Entiat Channel Restoration Project: Involved a variety of in-channel and bank treatments in association with riparian corridor roads and stream crossings in the

Stormy, Potato, Mud and Indian Creek drainages; Treatments included maintenance of burned area rehab check dams in Stormy and Potato Creeks, installation of low-profile, upstream pointing rock weirs, and large woody debris placement in channel sections adjacent to corridor roads and at stream crossings. ($45,000)

- Entiat Area Road Rehabilitation: Involved drainage improvement and stabilization work on lower Shady Pass and in the Silver-Pope, Mud, Tillicum and Indian Creek drainages; Treatments included drain dip construction/reconstruction, ditch relief culvert installation/rehab, prism reshaping, spot surfacing, armoring of stream crossings and weir placement. Completion of restoration work on the Tillicum fan site included removal of litter/metal debris and an unsafe wooden structure, removal of old concrete structures, bridge abutment and toe slope stabilization, installation of vehicle barriers, spot surfacing, noxious weed removal, native grass seeding and shrub planting. ($99,000)

- Upper Mud-Potato Area Road Closures: Involved road closures and spot drainage improvements on some open road segments in the road system in upper Mud and Potato Creeks; Treated roads were those used during salvage and post-fire reforestation work, that were no longer needed for access; Treatments included drain dip installation, decompaction by sub-soiling (self-drafting) and revegetation (grass). ($30,000)

- Potato Creek Flood Repair: Involved repair of runoff damage to sections of the lower Potato Creek road and the North Fork Potato Creek road, resulting from a severe thunderstorm on 8/26/97. Treatments included slough removal, prism reshaping, culvert repair, crossing stabilization and revegetation.

- Mud Creek Meadows Soil Rehab: Involved sub-soiling (self-drafting) and grass seeding of several old log landings in the Mud Meadows area above the 5300-217 road. This work was conducted as part of a demonstration training on the use of the self-drafting, winged sub-soiler. ($4,000)

- McKenzie Ditch Irrigation Diversion Fish Screening Project: Fish screens at the McKenzie Ditch Irrigation Diversion were replaced. This project was completed by the WDFW Yakima Screen Shop with funding from BPA. ($40,000)

1998

- Hanan-Detwiler Irrigation Diversion Fish Screening Project: Fish screens at the Hanan-Detwiler Irrigation Diversion were replaced. This project was completed by the WDFW Yakima Screen shop with funding from BPA ($80,000)

- Martin Sanders Irrigation Diversion Fish Screening Project: Fish screens at the Martin Sanders Irrigation Diversion were replaced. This project was completed by the WDFW Yakima Screen shop with funding from BPA. ($7,000)

2000

- South Fork Mud Creek Relocation: Riparian road relocation in South Fork Mud Creek Road (#5340). This included 1.95 miles of new road constructed, 1.10 miles of road reconstructed and 1.85 miles of road obliteration. ($174,000)

2001

- Mud Creek Road Relocation: Approximately 3 miles of the Main Mud Creek road (#5300) relocated away from the riparian zone. This project included decommisioning 3.9 miles of road located within riparian zone. ($241,000)
- Entiat Instream Structure Installation: The Bureau of Land Management, in cooperation with WDFW and USFS, installed two engineered log jams at river mile 10.3, and two boulder barbs with root wads at river mile 15, in the fall of 2001. These projects were installed as part of an ongoing effort to restore habitat complexity in the Entiat River below the Potato Creek Moraine.
- Entiat Instream Structure Installation: The Natural Resource Conservation Service, in cooperation with the Chelan County Conservation District, USFWS, and BLM, installed two low profile rock cross vanes just below the fire station bridge, and an additional structure above the Dinkleman Canyon Road bridge, in the fall of 2001. The structures have added juvenile rearing and adult resting/holding pool habitat in the lower Entiat River.
- Stream Gaging Installation and Operations: BPA funded the purchase, establishment and operation of eight continuous recording/telemetered stream gages in the maintem Entiat and Mad Rivers and their tributaries. These gages were installed by the Chelan County Conservation District in conjunction with the Washington Department of Ecology's Stream Hydrology Unit. Six staff gages were also installed in tributaries to the Entiat. The operations included installation of the gages, telemetry, data recording, and associated activities. ($198,000)

2003

- Hanan-Detwiler Passage Improvements (BPA project number 2003-020-00): BPA recommended funding of this proposal by the WDFW Yakima Screen Shop (YSS) to complete pasage improvements withing a side channed of the Entiat River. This side channel is associated with the Hanan-Detwiler irrigation diversion. (No funding was available for this project as of 1/20/04).

2004

- Entiat Off-Channel Rearing Habitat: This is a cooperative salmon and steelhead restoration, enhancement, and bioengineering project aimed at helping endangered spring chinook salmon, endangered summer steelhead trout and other anadromous and resident salmonids within the lower Entiat River drainage. This project is to create approximately 0.4 miles of high quality, year round off-channel salmon and steelhead rearing habitat on WDFW owned land adjacent the mainstem Entiat River at RM 6.5, just upstream of Roaring Creek. This project was started in 2000. ($162,398)

- Jon Small Off Channel Rearing Pond: The Jon Small Off-Channel Rearing Pond provides additional habitat for salmonids. This is a cooperative salmon and steelhead restoration, enhancement, and bioengineering project aimed at helping endangered spring chinook salmon, endangered summer steelhead trout and other anadromous and resident salmonids within the lower Entiat River drainage. Objectives are to create a 0.2 acre off-channel rearing pond, creata a menadering 1000 ft. off channel rearing channel exiting the pond and connecting to the Entiat River, and restore a 1000 ft of previously channelized and degraded in-channel rearing habitat and eroding banks through bioengineering and placement of instream rock and fish habitat structures. This project was started in 2000. ($196,261)
- Stormy Creek Culvert Replacement: Chelan County Public Works received SRFB funding in 2000 and BLM money to replace a fish passage barrier under the County river road. This project will provide salmonid access to tributary habitat in Stormy Creek. In-kind assistance has been provided by the USFWS, WDFW USFS, and CCCD. Additional funding is being currently being sought from the USFS and the USFWS in order to complete the project in 2004 or 2005. ($185,000)

Mad River Assessment Unit, Entire Mad River Drainage

1992

- Cougar Creek Area Stream Crossing Rehab: Drainage improvement, site hardening and revegetation at 15 perennial stream crossings on the Tyee Ridge Road (5700) in the Billy and Cougar Creek watersheds. Treatments included installation of drain dips, armoring of culvert inlets, outlets and fill slopes, pit-run surfacing at stream crossings, installation of slash filter windrows, revegtation, along with rehabilitation of adjacent non-system roads and disturbed areas. ($62,000)

1995

- Indian Creek Flood Repair: Involved repair of spring runoff damage on the Indian Creek crossing on the Tillicum Road; Treatments included trash rack removal, road surface repair, ditch and culvert cleaning, and fill slope reconstruction. ($5,000)
- Tyee-Sugarloaf Road Rehab: Involved spot treatment of problem road sections in the Mad River watershed; Treatments included drainage improvements (2 culverts in Windy Creek; 3 in tillicum/Indian Creeks; drain dips), prism reshaping, spot surfacing, fill slope stabilization and revegetation. ($45,000)
- Horan Irrigation Diversion Fish Screening Project: Fish screens at the Horan Irrigation Diversion were replaced. This project was completed by the WDFW and the Yakama Screen Shop with funding from BPA. ($20,000)

1996

- Tillicum-Miners Road Rehab: Involved road drainage improvement (drain dips, culverts) cut slope stabilization, surfacing and revegetation on the lower Indian Creek Road. ($38,000)

- Indian Creek Culvert Replacements: Involved the replacement of two existing, round corrugated metal culverts that were fish passage barriers with open bottom arch culverts. ($54,000)
- Tyee-Berg Road Rehab: Involved drainage improvement (dip improvement/installation), pit-run surfacing and revegetation on the upper Tyee Ridge Road (5700). ($86,000)
- Tillicum Fan Restoration: Involved revegetation work on the alluvial fan at the mouth of Tillicum Creek; Treatments included soil decompaction (moldboard plow, disc, harrow), grass seeding, alfalfa cultivation, tree planting and noxious weed removal (hand pulling). This project was completed in 1997 as part of the Entiat Area Road Rehab project. ($10,000)

1997

- Entiat Channel Restoration Project: Involved a variety of in-channel and bank treatments in association with riparian corridor roads and stream crossings in the Stormy, Potato, Mud and Indian Creek drainages; Treatments included maintenance of burned area rehab check dams in Stormy and Potato Creeks, installation of low-profile, upstream pointing rock weirs, and large woody debris placement in channel sections adjacent to corridor roads and at stream crossings. ($45,000)
- Entiat Area Road Rehabilitation: Involved drainage improvement and stabilization work on lower Shady Pass and in the Silver-Pope, Mud, Tillicum and Indian Creek drainages; Treatments included drain dip construction/reconstruction, ditch relief culvert installation/rehab, prism reshaping, spot surfacing, armoring of stream crossings and weir placement. Completion of restoration work on the Tillicum fan site included removal of litter/metal debris and an unsafe wooden structure, removal of old concrete structures, bridge abutment and toe slope stabilization, installation of vehicle barriers, spot surfacing, noxious weed removal, native grass seeding and shrub planting. ($99,000)
- Upper Indian Road Rehab: Involved repair of spring runoff and storm damage in Upper Indian Creek and Hornet Creek; Treatments included culvert improvement, drain dip installation and fill slope stabilization. ($5,000)

1998

- Tillicum-Moe Road Rehab: Road improvements on Road # 5810 Moe Ridge and Road # 5800 Tillicum Creek Road. This work included construction and reconstruction of drain dips, road drainage improvements, spot surfacing, ditch pulling of 3.21 miles of road #5810. This project also included insloping of existing road prism for drainage improvement, spot surfacing, ditch cleaning, and general blading and shaping of 5.16 miles of road #5800. Total project cost was $71,000 and the contract completed 10/26/98.

1999

- Indian Creek Dispersed Site Rehab: Decompaction, traffic control and revegetation of dispersed campsite/sheep bedding area at the mouth of Indian Creek, including rework of outlet rock on lower arch. ($1,000 10/99)

2002

- Stream Gaging Installation and Operations: BPA funded the purchase, establishment and operation of stream gages in eight critical reached of the Entiat and Mad Rivers. These gages were installed by the Chelan County Natural Resource Program and the Chelan County Conservation District in conjunction with the Washington Department of Ecology's Stream Hydrology Unit. The operations included installation of the gages, telemetry, data recording, and associated activities. ($198,000) Cut and paste from previously corrected gaging paragraph…

Middle Entiat Assessment Unit

Potato Moraine (RM 16.2) to Entiat Falls (RM 34)

1993

- Tyee-Shamel Creek Area Road Rehabilitation: Involved road rehab work on the dense road network in the Shamel Face area; Treatments included drainage improvements (drain dips, ditch relief culverts) and spot surfacing on open roads, as well as road closures (14 miles) and decommissioning (11 miles), with revegetation. ($35,000)
- Silver-Pope Area Road Rehabilitation: Stabilization of four major stream crossings and drainage improvement on adjacent road sections on the 5901/5902 roads. Treatments included rip-rap armoring of crossings, gravel surfacing, installation of 2 sub-surface drains, drain dips, and revegetation (alder planting, grass seeding and fertilization). ($34,000)
- Tommy-Silver-Pope Alder Planting: Involved the planting of surplus alder starts (from Entiat FSL) on a number of cut slopes in the Silver-Pope area (approx. 5 acres) and on two debris avalanche tracks in Tommy Creek (approx. 7 acres)

1994

- Lake Creek Road Rehabilitation: Involved road rehab work in the Lake Creek basin on the 5904 road and spurs; Treatments included armoring of crossings, spot surfacing, installation of 2 sub-surface drains, drain dips, culvert improvement/installation, cut/fill slope reshaping/armoring (rock, logs) and revegetation; This project was contracted in 1994 and was completed in two parts. Lake "Early" was completed in 1994 ($27,000). Lake "Late" was completed in 1995 ($80,000)
- Lower Tyee Road Prep: Involved preparation of the lower Tyee Road for paving/re-paving; Treatment included cut slope reshaping, ditchline refinement, ditch relief culvert installation and prism reshaping in unpaved sections of this road; This project was partially completed in 1994, shut down during the Tyee Fire and completed in the 1995 field season. ($86,000)

- Tyee Fire Emergency Burned Area Rehabilitation: A massive amount of burned area rehabilitation work was accomplished in the fall of 1994 on roads within the fire area (see Final Accomplishment Report for 1994 Chelan Fires)
- Tommy Creek Road Rehab: Involved road rehab work on the Tommy Creek Road system; treatments included stream crossing stabilization, drain dip installation, surfacing to the new trailhead, and road closures, with revegetation. The project was contracted in 1994 and completed in 1995 under two separate contracts. ($12,000)

1995

- Many of the road rehab projects contracted in 1994 were completed during the 1995 field season, as noted above.
- Tyee Fire Emergency Burned Area Rehabilitation work was continued during the 1995 field season, including the following road-related projects.
- Stormy Creek Check Dam Maintenance: Involved rework of ten loose rock check dams in lower Stormy Creek to better define the main channel, protect vulnerable banks and begin restoration of fish passage. ($2,300)
- Potato-Stormy "Early" Road Rehab: Involved drainage improvement (drain dip/culvert installation), stream crossing/fill slope stabilization, temporary road relocation, spot surfacing and revegetation on roads in the lower Stormy Creek drainage, in response to damage from spring runoff. ($30,000)
- Pope Creek Flood Repair: Involved restoration of the Pope Creek crossing on the Entiat Valley Road following passage of a debris torrent initiated by spring runoff. ($8,000)

1996

- Shamel Creek Road Rehab: Involved repair of one culvert crossing that had been damaged during spring runoff. ($4,000)
- Lake Creek Area Road Rehab: Involved completion of drainage improvement and slope stabilization work on the Lake Basin Road (5904) that was started in 1994. Also involved drain dip installation on a portion of the Shady Pass road, culvert improvement at a crossing on the Tommy Creek road and reshaping/resurfacing of a portion of the Tillicum Creek Road (above Tillicum Creek crossing). ($81,000)

1997

- Entiat Channel Restoration Project: Involved a variety of in-channel and bank treatments in association with riparian corridor roads and stream crossings in the Stormy, Potato, Mud and Indian Creek drainages; Treatments included maintenance of burned area rehab check dams in Stormy and Potato Creeks, installation of low-profile, upstream pointing rock weirs, and large woody debris placement in channel sections adjacent to corridor roads and at stream crossings. ($45,000)

- Shamel/Byers Road Repair: Involved repair of spring runoff damage to a culvert crossing on Shamel Face and a section of road in Byer's Canyon needed for reforestation access; Treatments included culvert improvement, running surface repair, drain dip installation and revegtation. ($6,000)
- Entiat Area Road Rehabilitation: Involved drainage improvement and stabilization work on lower Shady Pass and in the Silver-Pope, Mud, Tillicum and Indian Creek drainages; Treatments included drain dip construction/reconstruction, ditch relief culvert installation/rehab, prism reshaping, spot surfacing, armoring of stream crossings and weir placement. Completion of restoration work on the Tillicum fan site included removal of litter/metal debris and an unsafe wooden structure, removal of old concrete structures, bridge abutment and toe slope stabilization, installation of vehicle barriers, spot surfacing, noxious weed removal, native grass seeding and shrub planting. ($99,000)
- Entiat River Bank Stabilization and Fish Habitat Restoration Project: Involved more than 1300 feet of bank treatments called "rootwad revetments" followed by riparian shrub plantings during September 1997. Treatments included placement of more than 100 conifer logs with rootwads, erosion control seeding, and planting more than 10,000 native shrubs on private lands in the "Stillwaters" reach of the Entiat River. The project was accomplished by 10 partners. ($153,000)

1998

- Tyee Lookout Road Drainage Improvement: Installation of 46 drain dips and road drainage improvements on 3.85 miles of # 5713 Tyee Lookout road. (8/98, $2,000.00)
- Preston-Dill Road System Storm Damage Repair: Backhoe work on plugged culverts on roads # 5501, # 5502, # 5503. Removal of storm caused small slides and clearing of debris plugged ditches (8/25/98 $3000.00)

1999

- Tommy Creek Dispersed Site Rehab: Decompaction, traffic control and revegetation of dispersed campsite roads along lower Tommy Creek Road. ($4,000 10/99)
- Stormy Creek Check Dam modification: Third and last modification of the loose rock check dams installed in lower Stormy Creek during the 1994 Tyee BAER. ($5,000 10/99)
- Upper Entiat Spawning Channel Restoration: Approximately a quarter mile of previously constructed spawning channel was repaired. Since repair, spring chinook, steelhead and occasionally bull trout have been observed spawning in the channel. (8/04)

2000

Property Acquisitions: The Chelan-Douglas Land Trust received grant monies from the State Salmon Recovery Funding Board to purchase property along the mainstem Entiat River for the protection of properly functioning riparian/fish/wildlife habitat.

2001

- Property Acquisitions: The Chelan-Douglas Land Trust received grant monies from the State Salmon Recovery Funding Board to purchase property along the mainstem Entiat River for the protection of properly functioning riparian/fish/wildlife habitat.

2002

- Tommy Fire BAER: 220 acres of uplands were aerially seeded and the drainage on 3 miles of trail was improved following the Tommy Fire. ($12,400)
- Entiat River Road Resurfacing: gravel surfacing was added to approximately one mile of road ($40,000).
- Stream Gaging Installation and Operations: BPA funded the purchase, establishment and operation of stream gages in eight critical reached of the Entiat and Mad Rivers. These gages were installed by the Chelan County Natural Resource Program and the Chelan County Conservation District in conjunction with the Washington Department of Ecology's Stream Hydrology Unit. The operations included installation of the gages, telemetry, data recording, and associated activities. ($198,000) Use previously edited gaging paragraph…

2003

- Riparian Road Relocation: Spot seeding and mulching was applied to a two mile section of the Mud Creek Road that was decommissioned in 2001. ($3800)

2004

- Entiat River Road Barrier Removal: This project is to replace an existing fish block culvert on Chelan County Road # 94470 (Entiat River Road) with a bottomless arch threrby aloowing steelhead and jucenile spring chinook salmon immediate access to one half mile of properly functioning rearing habitat in lower Stormy Creek, a significant, perennial tributary in the mid-Entiat River.

Upper Entiat Assessment Unit

Entiat Falls (RM 34) to top of Drainage

1998

- Steliko Stream Rehab: This project entailed fixing a leak in the channel retaining wall and excavation and replacement of water pipe behind the barn. $4,004.00; project completed 9/9/98.

1999

- Upper Entiat River Road Rehab: Spot surfacing and drainage improvements on approximately 2 miles of the Upper Entiat River Road; included surfacing Three Creek and Spruce Creek CG access roads. ($20,000 10/99)

2003

- Spruce Grove Campground Restoration: A buck and pole fence was erected to reduce recreation impacts on the riparian area. ($3000)
-

Basin Wide Projects

2003

- Comprehensive Inventory and Prioritization of Fish Passage and Screening Problems in the Entiat and Entiat Subbasins: BPA recommended funding of this proposal by the WDFW Yakima Screen Shop (YSS) to locate and evaluate all culverts, dams, fishways, water diversions, and other human-made features in the Entiat and Entiat subbasins; conduct fish habitat assessments; and prioritize all barriers and unscreened or inadequately screened water diversions. (No funding was available for this project as of 1/20/04).
- Columbia Cascade Province Pump Screening: BPA recommended funding of this proposal by the WDFW YSS to perform a comprehensive re-assessment, re-inventory, and mitigation of previously inventoried pumps screen sites in the Entiat, Entiat, and Methow subbasins. (Don't know about $$ -- assume same as above?)

6 Synthesis and Interpretation

6.1 Introduction

In general, many fish and wildlife habitat attributes in the Entiat Subbasin are in good condition, especially in the upper portions of the subbasin. Attributes in the lower Entiat and Mad rivers have changed the most from the historic reference condition through agricultural and rural developments. Because of flood control measures and agricultural practices, the lower Entiat River has seen significant channel and riparian simplification and lost floodplain function which is the primary factor limiting anadromous salmonid production in the subbasin.

Low stream channel complexity is the primary limitation to productivity of salmonids on the lower 20-km of the mainstem Entiat River (downstream of the terminal moraine). Stream sinuosity is low, with very few point bars for gravel accumulation. Instream habitat diversity is also low, with few pools, glides, pocket waters or large woody debris accumulations. As a result, there are very few resting areas for both adult and juvenile salmon through this important migration corridor. Additionally, changes in channel shape have substantially increased the stream width to depth ration, exacerbating low flow and extreme water temperature conditions. Efforts to improve stream sinuosity and channel forming processes in the lower reach should be considered.

Overall, chinook and steelhead production in the Entiat River could increase if habitat problems within the lower subbasin were rectified. Increasing off channel habitat, increasing habitat diversity and structural complexity, moderating extreme water temperatures and restoring riparian areas and function in the lower Entiat River would increase adult holding and juvenile rearing habitat and to a lesser degree could increase spawning habitat as well. Creating or restoring more habitat may not increase overall production by a large degree, but it will increase the spatial and potential genetic diversity of these species in the Entiat River.

Bull trout and Westslope cutthroat trout populations are considered to be relatively healthy and may be on an improving trend within the Entiat subbasin. However, the status of bull trout is not well understood in the upper Entiat River watersheds above Entiat Falls. Reduction of sport harvest on bull trout is likely the primary reason for this trend, while harvest on cutthroat is not well documented. Habitat conditions in spawning and rearing areas is in good and stable condition. Brook trout do inhabit and compete with cutthroat and bull trout and are likely one of the key factors limiting production of these native species. Habitat improvements in the lower Entiat would likely benefit adult bull trout migration and holding.

6.2 Key Habitat – Population Relationships

Spring chinook

Adult migration and holding: Spring chinook enter the Entiat River from May through June and hold (stage) until spawning begins in August in larger pools of the Entiat and Mad rivers. Loss of riparian area (and associated large wood that is used as cover) and loss of natural geo-fluvial processes have reduced the abundance of pools. Mortality, stress or displacement to adults is likely greatest in the lower Entiat Assessment Unit, but occurs in lower Mad and Middle Entiat as well.

Spawning and egg incubation: Spawning and egg incubation areas within the Entiat subbasin has been substantially altered. Spawning substrates are embedded in some areas, and natural geo-fluvial processes have been compromised, so gravel recruitment is low, and sedimentation is high. Losses of riparian areas, channel stability, and habitat diversity have all impacted spring chinook spawning. Changes in channel morphology and lost habitat diversity likely leave some redds more susceptible to disturbance or destruction due to high flow events and bedload movement.

Rearing: Rearing habitat for fry and parr has been compromised by channel simplification, loss of riparian area and large wood in the stream channel. In the Lower Entiat AU, off channel habitat, channel stability, and habitat diversity are substantially lacking. Winter rearing habitat may be limiting to spring chinook juveniles because of natural temperature regimes especially in the lower Entiat River.

Conclusion: Spring chinook production in the Entiat River could increase if habitat problems within the lower basin were rectified. Preservation of quality spawning and rearing habitat in the Middle Entiat AU is important to maintain naturally reproducing populations. Increases of off channel habitat and riparian areas in the lower Entiat River would increase potential rearing habitat and life history diversity. Creating or restoring habitat will increase spring chinook productivity by a modest degree, and increase the spatial and potential life history diversity within the Entiat River.

Late-run chinook

Late-run chinook enter the Entiat River from June through October and hold until spawning begins in October in larger pools of the mainstem Entiat. Similar to Spring chinook, loss of riparian area (and associated large wood that is used as cover) and loss of natural geo-fluvial processes have reduced the abundance of pools. Mortality, stress or displacement to adults is likely greatest in the lower Entiat Assessment Unit and to a lesser degree in the Middle Entiat.

Spawning and egg incubation: Summer/fall chinook of the Entiat Basin spawn in the mainstem Entiat River in both Lower and Middle Assessment Units. Impacts to late-run chinook are similar to those mentioned for spring chinook.

Rearing: Impacts to rearing late-run chinook are similar as those effecting spring chinook.

Conclusion: Summer/fall chinook production in the Entiat River could increase if habitat problems within the lower river were corrected. Increases of off channel habitat and riparian areas in the lower Entiat River would increase productivity by increasing potential rearing, adult holding habitat, and genetic, spatial, and life history diversity.

Coho

Adult migration and holding

Reintroduced coho salmon will likely enter the Entiat River in early September through late November. Coho entering in September and October will hold in larger pools prior to spawning, later entering fish may migrate quickly upstream to suitable spawning locations. As observed in the Wenatchee Rier, during years with extreme low flow, coho entrance into the Entiat River or migration to spawning grounds may be delayed. Loss of riparian area (and associated large wood that is used as cover) and loss of natural geo-fluvial processes have reduced the abundance of pools. As described for spring chinook, mortality, stress or displacement to adults will likely greatest in the lower Entiat Assessment Unit, but occurs in lower Mad and Middle Entiat as well.

Spawning and egg incubation

Spawning areas for coho salmon in the Enitat River have been substantially altered. Spawning substrates are embedded insom areas, and natural geo-fluvial processes have been compromised, so gravel recruitment is low, and sedimentation is high. Losses of riparian aras, channel stability, and habitat diversity have all impacted coho spawning habitat. Changes in channel morphology and lost habitat diversity likely leave some redds more susceptible to disturbance or destruction due to high flow events and bedload movement.

Rearing

Rearing habitat for fry and parr has been compromised by channel simplification, loss of riparian area and large wood in the stream channel. In the Lower Entiat AU, off channel habitat, channel stability, and habitat diversity are substantially lacking.

Conclusion

Coho are in need of reintroduction to the Entiat River. As coho are reintroduced productivity could be increased if habitat problems were improved. Preservation of quality habitat in the middle Entiat AU is important to developing a naturally reproducing coho population. Increases in off channel habitat and riparian areas in the lower Entiat River would increase potential rearing habitat, over-winter survival and life history diversity. Creating or restoring habitat will increase the success of reintroduction efforts within the Entiat River.

Steelhead

Adult migration and holding: Steelhead enter the Entiat River from August through May of the following year and hold in larger pools or deeper glides until spawning begins in February. Steelhead hold primarily in the mainstem Entiat as well as the spawning tributaries. As mentioned with Chinook salmon above, lost pool habitat and habitat diversity likely displaces steelhead from holding in many areas within the lower and middle assessment units, and to a lesser degree in the Mad River.

Spawning and egg incubation: Steelhead primarily spawn in habitats that have been altered by land use activities and natural processes. Spawning gravel is embedded in the mainstem and tributary streams. Natural geo-fluvial processes have been compromised, so gravel recruitment is low, and sedimentation is high. Steelhead egg incubation survival is likely reduced for the same reasons as described for chinook salmon above.

Rearing: See spring chinook rearing above.

Conclusion: Steelhead production in the Entiat River could increase if habitat problems within the lower basin were rectified. Preservation of quality spawning and rearing habitat in the Mad and Middle Entiat AU is important to maintain naturally reproducing populations. Increases of off channel habitat and riparian areas in the lower Entiat River would increase potential rearing habitat and life history diversity. Creating or restoring habitat will increase steelhead productivity by a modest degree, and increase the spatial and potential life history diversity within the Entiat River.

Bull trout

Adult migration and holding: Bull trout of the Entiat River may live their entire lives within it, or may migrate between the Mad, Entiat, and mainstem Columbia R Bull trout of the Entiat Basin primarily spawn primarily in the upper Mad River in habitat that has either been preserved or is in relatively good condition. Bull trout are also known to spawn in the mainstem Entiat but it is uncertain to what degree.

Bull trout of the Entiat Basin primarily spawn primarily in the upper Mad River in habitat that has either been preserved or is in relatively good condition. Bull trout are also known to spawn in the mainstem Entiat but it is uncertain to what degree.

Rearing: Rearing habitat for fry and parr is in generally good condition, however winter rearing has been compromised by loss of riparian area, off channel habitat, channel stability, and habitat diversity.

Conclusion: Bull trout production in the Entiat River Basin could increase if habitat problems were rectified. Potentially increases of off channel habitat and riparian areas in the lower Entiat River, would increase potential rearing and adult holding habitat and life history diversity. While creating or restoring habitat may not increase overall bull trout production by a significant degree, it does increase the spatial and potential genetic diversity of bull trout in the Entiat River.

Bull trout are more sensitive than other species to habitat degradation. Water quality requirements for bull trout require the preservation and restoration of high functioning habitat. Processes that affect temperature, sediment load and connectivity from lower quality (feeding areas) to higher quality (spawning and initial rearing areas) should all be considered when trying to increase overall production of bull trout.

Westslope Cutthroat Trout

Life History

Westslope cutthroat trout (WSCT) generally exhibit three main life histories forms; fluvial, which migrate between smaller spawning stream and larger rearing streams; adfluvial, which migrate between spawning streams and a lake, and non-migratory, which generally spend their entire lives in the stream they were born in. Much of the life history of WSCT in the Entiat Subbasin is unknown.

Adult migration and holding

WSCT may live their entire lives in the tributaries to the Entiat and Mad rivers or they may migrate to the mainstem and possibly to the Columbia River. When adults are migrating upstream to spawning areas, they associate with cover; debris, deep pools and undercut banks. The availability of and number of deep pools and cover is important to offset potential prespawning mortality. Adult cutthroat trout need deep, slow moving pools that do not fill with anchor ice in order to survive the winter. Intact riparian habitat will increase the likelihood of instream cover, and normative channel geofluvial processes will increase the occurrence of deeper pools.

Spawning and egg incubation

WSCT spawn between March and July, when water temperatures begin to warm. Spawning and rearing streams tend to be cold and nutrient poor. Stream conditions (e.g. frequency of flooding, extreme low temperatures) may affect egg survival. Flood can scour eggs from the gravel by increasing sediment deposition that reduces oxygen and percolation through the redd.

In the Entiat Subbasin, fall flooding has a high frequency of occurrence. This may negatively affect incubation and emergence success, especially in years of extreme flows. Fire and other disturbances in the upper watershed may increase siltation. Maintaining a high degree of habitat complexity in these areas is important to maintaining and enhancing these populations.

Rearing

After emergence, fry are usually found in shallow, slow backwater side channels or eddies, in association with fine woody debris. Juvenile cutthroat trout overwinter in the interstitial spaces of large stream substrate. Rearing habitat in Mad, and upper Entiat rivers is currently in good condition.

Conclusion

Westslope Cutthroat Trout production in the Entiat Subbasin is likely to remain healthy given existing environmental conditions persist. Preservation of quality habitat in upper tributaries and small streams within the watershed would ensure remaining high quality habitat areas remain in tact. Production of cutthroat trout could increase if brook trout control programs were implemented successfully.

Pacific lamprey

Currently there is not enough information concerning this species in the Entiat subbasin to draw conclusions.

6.3 Determination of Restoration Priorities

The Entiat River has been affected by upland management activities throughout the subbasin and construction of flood control dikes in the lower mainstem. To encourage properly functioning and stable habitats in the subbasin, four actions should be approached simultaneously:

- Protect core subwatersheds in the upper subbasin and upper Mad River
- Continue restoration of highly erosive upland areas in Fox, McCree, Brenegan, Preston, and Mud creeks, Crum Canyon, and the mainstem Entiat between Fox and Stormy creeks
- Restore habitat diversity and channel function in the lower Entiat River
- Increase late summer instream flows in the lower Entiat and lower Mad rivers

Upland erosion is a severe chronic problem in the Entiat Watershed, yet substantial restoration efforts are underway in the Entiat National Forest to address this problem. Erosion on private lands contributes little to the overall problem of sediment delivery to the stream.

Low stream channel complexity is the primary limitation to productivity of salmonids on the lower 20-km of the mainstem Entiat River (downstream of the terminal moraine: Category 2). Stream sinuosity is low, with very few point bars for gravel accumulation. Instream habitat diversity is also low, with few pools, glides, pocket waters or LWD accumulations. As a result, there are very few resting areas for both adult and juvenile salmon through this important migration corridor. Efforts to improve stream sinuosity and channel forming processes in the lower reach should be implemented.

Based on the work of NRCS, we believe the most feasible means to restore habitat in the lower Entiat River is primarily in structure placement as an immediate improvement, and floodplain restoration as the long-term solution. This short term/long term approach is the most pragmatic restoration practice available for the lower Entiat River. Initially, managers should actively restore the lower Entiat River to increase stream habitat complexity, encourage thalweg development, and deposition of spawning gravels. The long-term approach should be to restore riparian and floodplain habitat in the lower Entiat River. Such measures would also be feasible in the lower Mad River.

A multi disciplinary team of fishery biologists, hydrologists, and fluvial geomorphologists can provide specific recommendations on the types of structures that would work best, based upon channel configuration. Active restoration projects will be reviewed on a case-by-case basis. We caution that these approaches to increase productivity are short-term, and may require maintenance. The lower Entiat River is one of the few watersheds in the Upper Columbia Region where active manipulation of the stream channel is appropriate.

The most pressing needs on the lower Entiat River are the lack of instream complexity and riparian cover, yet there are other factors that adversely affect salmonids. Instream flows limit salmonid production in the lower Entiat River, but not to the chronic and severe extent seen in other subbasins of the Upper Columbia Region. This is partly a result of the natural characteristics of the watershed, upland slope condition, irrigation water withdrawals, and stream channel modifications in lower Entiat River. Projects that increase late summer flows in the lower Entiat River should be an important component in salmonid recovery.

Priorities in Species Distribution

Threatened, endangered and unlisted salmonids are found in most, but not all watersheds in the Upper Columbia Region. In order to help guide protection and restoration programs, the Regional Technical Team (RTT) adapted the work of MacDonald et al. (1996) who identified Significant Subwatersheds (HUC-6 level) for spring chinook salmon, summer chinook salmon, sockeye salmon, summer steelhead, bull trout, and westslope cutthroat trout. Based on the framework established by MacDonald et al. (1996), the RTT considered a subwatershed to be significant if any one of the following criteria was met:

The subwatershed was identified as a stronghold for the species in the Interior Columbia Basin Assessment (ICBEMP 1997).

The subwatershed provides the primary spawning and/or rearing habitat within the watershed.

The subwatershed represents the only known occupied habitat within a watershed and is fairly isolated from populations in other watersheds, and thus is significant from a distribution standpoint.

The subwatershed contributes toward the genetic integrity of a species. One of the problems facing many native fish populations is genetic introgression. Relatively pure populations, which may be very important to the evolutionary legacy of a species, may be limited. Recently genetic information has become available for some populations in the Upper Columbia Region. Populations judged to be “pure,” “essentially pure,” or “good” based upon genetic analysis were considered to be significant.

The subwatershed is known or strongly suspected to support a stable, strong population of a species.

Appendix C contains maps of RTT identified Significant Subwatersheds for sockeye salmon, spring chinook salmon, summer chinook salmon, steelhead, and bull trout. The designation of Significant Subwatershed does not necessarily depict the total distribution or life history stages of salmonids in the Upper Columbia region. The status of some salmonid species is not fully known.

Priorities Across Varied Landscapes

The consensus of the RTT is that protection and restoration should focus first on maintaining the best remaining examples of biological integrity, connectivity, and diversity. This strategy will allow the populations to stabilize in abundance and productivity over the long term. It may be likely however, that current core populations have inadequate diversity and spatial distribution to ensure population resiliency.

To provide a framework to set priorities consistent with this strategy, the RTT classified each watershed (HUC-5 level) in the Entiat subbasin into four categories, based on the functionality of the aquatic ecosystems in those watersheds, and the capability of the ecosystem to protect against ecological catastrophe for endemic populations. The RTT adapted the classification system used by Quigley and Arbelbide (1997) for this report. In general, Category 1 watersheds should receive priority allocation of financial and/or management resources. Subsequent allocation of resources should be given to Categories 2 and 3, in that order, once refuge habitats (Category 1) for the target species are protected and secure. This does not mean however, that specific actions should not occur in Category 2 and 3 watersheds until all activities in Category 1 watersheds are completed. Any project within those watersheds that increase the range, life history diversity, or age cohorts of one or more species would contribute to the overall strategy of making them more robust to disturbances within and outside the region. As salmon recovery progresses, founder populations from core areas would colonize many watersheds that are suitable, yet unoccupied. Restoration of Category 4 watersheds should be considered in the regional recovery planning process, but immediate actions there would not be a priority.

Category 1

These watersheds represent systems that most closely resemble natural, fully functional aquatic ecosystems (Table 22). In general, they comprise large, often continuous blocks of high-quality habitat and subwatersheds supporting multiple populations. Connectivity among subwatersheds and through the mainstem river corridor is good, and more than two species of federally listed fish are known to occur. Exotic species may be present but are not dominant. Protecting the functioning ecosystems in these watersheds is a priority.

Category 2

These watersheds support important aquatic resources, often with subwatersheds classified as strongholds for one or more populations throughout. The most important difference between Category 1 and Category 2 is an increased level of fragmentation that has resulted from habitat disturbance or loss. These watersheds have a substantial number of subwatersheds where native populations have been lost or are at risk for a variety of reasons. At least one federally listed fish species can be found within the watershed. Connectivity among subwatersheds may still exist or could be restored within the watershed so that it is possible to maintain or rehabilitate life history patterns and dispersal. Restoring ecosystem functions and connectivity within these watersheds are priorities.

Category 3

These watersheds may still contain subwatersheds that support salmonids. In general, however, these watersheds have experienced substantial degradation and are strongly fragmented by extensive habitat loss, most notably through loss of connectivity with the mainstem corridor. At this time, there are limited opportunities for restoring full expression of life histories for multiple populations found within the watershed. The priority for funding in these watersheds should be to rectify the primary factor that is causing the habitat degradation.

Category 4:Table 1

These watersheds contain both functional and non-functional habitats that historically supported populations of one or more federally listed species (Table 1). Exotic species may now be dominant in one or more subwatersheds; native species are typically not present in sustainable numbers.

Table 22. Comparison of key indicators for watershed categories used to identify priority actions for protection and restoration of salmonid habitat the upper Columbia region.

Category	Significant Subwatersheds	Principle Actions	Habitat Fragmentation	Exotic Species	Listed Species
1	Yes	Protection	Low	Low	Two or more
2	Yes	Protection / Restoration	Medium	Medium	One or more
3	Possible	Restoration	High	High	Possible
4	No	Restoration	High	High	Possible

Priorities in Habitat Activities

Habitat Protection

The highest priority for protecting biological productivity should be to allow unrestricted stream channel migration, complexity, and flood plain function. The principal means to meet this objective is to protect riparian habitat in Category 1 and 2 subwatersheds. Predetermined riparian protection measures (i.e., buffer strip widths) for each site may not be biologically effective. Riparian function depends on site-specific considerations including channel type, floodplain character, presence of wetlands or off-channel features, and the potential for channel migration. Obviously, some areas have more acute needs, because they may be within significant population areas, or may be at risk to habitat degradation, and should be given greater emphasis. These efforts will likely occur throughout the subbasins where properly functioning habitat remains.

Protection of existing stream flows in virtually all watersheds in the Entiat Subbasin is important to maintaining biological productivity. Currently, the primary means to protect existing flows are regulatory in nature. Additionally, some streams may need increased flows to address chronic sources of mortality to salmonids; inadequate flows may be natural or human-caused. Diversion of water for out-of-stream uses (principally for irrigation and municipalities) is the most tangible impact to instream flow needs for fish. In addition, degradation of floodplain (and some upland) habitats exacerbates the peak and nadir of seasonal flows in all Upper Columbia subbasins; this strongly reduces the productivity and expression of diverse life histories in the region. The full effects of upland habitat degradation on peak flows in the Entiat Subbasin are not understood and should be assessed. The means to increase flows are discussed in the section on habitat restoration.

Habitat Restoration

The highest priority for increasing biological productivity is to restore the complexity of the stream channel and floodplain. The RTT recommends a range of strategies for habitat restoration in the Upper Columbia Region, based on a fundamental emphasis of promoting habitat diversity, instream flows, and water quality throughout the watershed. Most of these efforts will likely be on the lower stream reaches and aggradation zones (typically areas of low stream gradient where deposition of substrate materials occurs). Restoration in these areas would benefit a broad range of species and populations.

The RTT Biologic Strategy (2003) strongly recommends that structural manipulation of the stream channel (such as boulder or log placements) not be used unless (1) they are designed at the reach level or context and (2) those factors that are causing the habitat degradation cannot be corrected within a reasonable time. Remedial measures to rectify the effects of improper land use practices can have more benefits to biological productivity, may be economically more efficient, and be more permanent than measures that require active management of the stream channel. The simple alteration of physical features in the stream channel does not necessarily restore biological productivity when improper riparian or upland management practices continue to exert their effects on the aquatic ecosystem. Attempts to restore habitat are likely to fail if structures are placed in the stream channel without addressing those activities that are causing habitat degradation. For example, some short-term habitat benefits might be achieved by adding large woody debris to streams, but the benefits can only be temporary from an ecological perspective unless riparian management practices ensure the long-term recruitment of LWD from the riparian zone.

In some isolated situations, restoration projects may be accomplished with both short-term and long-term objectives. For example, LWD may be secured to stabilize erosive banks, allowing interim streambank protection and salmonid habitat, while passive restoration and re-vegetation will ensure proper functioning riparian conditions for the long term. We feel these projects are biologically effective when the initiation of the short-term strategy has been integrated with the long-term strategy. Each active restoration project should be reviewed on a case-by-case basis.

Table 23. Categories of watersheds

Watershed	Category	Significant Watersheds
Upper Entiat	1	2
Middle Entiat	1	2
Lower Entiat	2	0
Mad River	1	3

Note: (HUC-5 level) and number of Significant Subwatersheds (HUC-6 level) within those watersheds in the Upper Columbia Salmon Recovery Region. Definitions of watershed categories and Significant Subwatersheds are provided in text.

6.4 Terrestrial/Wildlife

6.4.1 Key Findings

The terrestrial assessment viewed the subbasin from a perspective of key and major vegetative communities. Three community types were chosen as focal habitat for this evaluation, ponderosa pine, shrub steppe and riparian ecosystems. Within each of these focal habitats, representative species that are directly associated with these vegetative communities are identified and will be monitored.

Factors Affecting Ponderosa Pine Habitat

- Timber harvesting has reduced the amount of old growth forest and associated large diameter trees and snags.
- Urban and residential development has contributed to loss and degradation of properly functioning ecosystems.
- Fire suppression/exclusion has contributed towards habitat degradation, particularly declines in characteristic herbaceous and shrub understory from increased density of small shade-tolerant trees. High risk of loss of remaining ponderosa pine overstories from stand-replacing fires due to high fuel loads in densely stocked understories.
- Overgrazing has resulted in lack of recruitment of sapling trees, particularly pines.
- Invasion of exotic plants has altered understory conditions and increased fuel loads.
- Fragmentation of remaining tracts has negatively impacted species with large area requirements.
- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and may be subject to high levels of human disturbance.

Factors Affecting Shrubsteppe Habitat

- Degradation of habitat from intensive grazing and invasion of exotic plant species.
- Fire management, either suppression or over-use, and wildfires.
- Invasion and seeding of crested wheatgrass and other introduced plant species which reduces wildlife habitat quality and/or availability.
- Loss and reduction of cryptogamic crusts, which help maintain the ecological integrity of shrub-steppe/grassland communities.
- Human disturbance during breeding/nesting season, parasitism.

Factors Affecting Riparian Wetland Habitat

- Habitat degradation from livestock overgrazing which can widen channels, raise water temperatures, reduce understory cover, etc.

- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and be subject to high levels of human disturbance.

6.4.2 Aquatic/Fisheries

This synthesis and interpretation of information presented in the assessment section of this plan, focuses on key habitat features that affect the focal species. Focal species of the Entiat River are: spring and summer/fall chinook, steelhead, bull trout, and westslope cutthroat trout.

I. Key findings

Key Findings tie together the information from the subbasin assessment that discusses status of focal species and key habitat features and how the two work in concert.

Lower Entiat River Assessment Unit

Key Findings:

Temperature

- Water temperatures are believed to be elevated from historic levels.
- Conditions are exacerbated by land use practices during low flow years.
- Water temperature typically exceeds state water quality standards from July through September, although exceedences are usually of short duration and diurnal in nature.
- Very cold winter temperatures affects egg incubation survival, time of emergence, and winter rearing habitat for focal species and may also affect macro invertebrate production in some years.

Contaminants - Non-point Source Pollution

- Water quality for the Entiat River is generally in good to excellent condition.
- The use of herbicides and pesticides in lower Entiat may affect focal species health.
- Fecal coli form levels are generally below acceptable limits however, occasional exceedences of CWA standards have occurred.
- Unrestricted livestock access to streams may result in elevated fecal coli form levels.

Contaminants - Point Source Pollution

[No information to date]

Sediment

- The Lower Entiat lies within the depositional zone of the subbasin.
- Road densities, unstable banks, and natural/human caused disturbance events all contribute to fine sediment conditions.

- The 11-year trend of sediment deposition appears to be increasing.

Flow

- Mainstem and tributary flows are highly variable and very responsive to local weather.
- Peak flow timing is assumed to be at or near historic conditions, with current peak flows showing signs of recovery from past fires.
- Low flows are a natural occurrence within the subbasin.
- Irrigation water use during the low summer flow period, coupled with increased channel width-to-depth ratio in the lower Entiat River, may exacerbate poor conditions.

Riparian Conditions

- Riparian conditions near confluence with the Columbia River show vigor and contribute positively to stream channel diversity and properly functioning conditions.
- Channel straightening, clearing and diking/bank armoring have changed riparian and floodplain conditions.
- Riparian cover is reduced (in various degrees) and LWD recruitment is low. Filling and diking has eliminated floodplain connection in areas.
- In some reaches, loss of vigorous shrubs in the riparian zone has reduced instream organic input and shade, and contributed to unstable stream banks and associated erosion.
- Road densities are generally high and in close proximity to streams.
- These conditions have reduced available spawning, rearing and holding habitat for juveniles and adult focal fish species.

Habitat diversity, quantity, and channel stability

- Channel morphology has been simplified as a result of channel straightening/widening, diking, and bank armoring.
- The lower Entiat has been changed in many reaches to a Rosgen F type channel, resulting in a high width-to-depth ratio, channelization, stream down-cutting, and a substantial lack of habitat diversity.
- The amount of large woody debris is very low throughout the Assessment Unit.
- Pool habitat has been reduced by 80% (Entiat Watershed Plan) from historic conditions.
- Quality and quantity of rearing and holding habitat, off-channel winter rearing habitat, and spawning habitat have been reduced throughout most of the Lower Entiat River.

Barriers

- There are no physical structures in the lower mainstem Entiat River.

Pathogens

- Pathogens to salmonid species may have increased as a result of hatchery operations and fish species introductions.

Predation

- Bird and fish predation on salmonid juveniles is likely to have increased due to a lack of hiding cover.
- Smolt releases from the Entiat National Fish Hatchery result in increased avian predation.
- Reduced in-channel habitat diversity and development of Lake Entiat (Rocky Reach Hydro Project) have increased the abundance of non-native fish species, particularly predators such as the Northern Pikeminnow and bass.
- Mammal predation on adult salmonids is likely decreased from the historic reference condition due to displacement of these animals.

Food

- Food resources (macro invertebrate production) for juvenile salmonids have likely decreased since the historic reference condition as a result of increased water temperatures and decreased organic inputs and nutrient loads.
- Reduced salmonid carcasses, reduced riparian / leaf litter and reduced floodplain function have contributed to a lowering of the nutrient content and benthic macro invertebrate production within the lower Entiat.

Harassment

- Harassment of adult salmonids is largely a function of lack of hiding cover coupled with recreation use of the river.
- At this time there is no formal public outreach to educate people of the sensitivity of these fish to disturbance, especially during adult holding and spawning times.

Introduced Species

- Hatchery operations and past stocking may have reduced the genetic fitness of focal species and resulted in competition for habitat in the lower River.

Middle Entiat River Assessment Unit

Key Findings:

Contaminants - Non-point Source Pollution

Most water quality attributes are at or near pristine condition.

Sediment

- 11-year trend in mainstem appears to be a long term-decrease.
- 11-year trend for tributary streams is less clear, but also appears to be a long-term decrease.
- Riparian clearing and roading has resulted in bank erosion and increased sediment delivery in some areas.

Flow

- Flow conditions in the Middle Entiat Assessment Unit are at or near pristine conditions.
- Some alterations may exist due to past high intensity fires, although these conditions are considered to be within the range of natural variation.

Riparian condition

- Riparian condition and floodplain function has been reduced in many reaches with the exception of the Stillwaters area between Stormy and Preston Creeks.
- Fair conditions exist in localized areas (20-30% of AU stream area) where fire, riparian clearing / development, channel simplification (dikes to prevent channel migration) and grazing have resulted in accelerated channel migration and erosion.
- Roads are present in the riparian area near the mainstem Entiat River and some tributaries.
- Road densities in Preston and Brennegan creeks (most are contour roads that cross the creeks) are as high as 6mi/sq.mi.
- Riparian clearing and roading has resulted in a loss of side channel habitats, backwater pools and stream / riparian interface.

Habitat diversity, quantity, and channel stability

- Stream and fish habitat conditions have been reduced.
- General channel features, such as sinuosity, width/depth ratios exhibit near normal features. Localized bank erosion, and loss of habitat diversity and channel complexity is apparent due to stream channel clearing and development.
- In low-gradient areas, loss of side channel habitat has resulted to a loss of off-channel refugia during high flows.
- Where off-channel habitat does exist, it is in stable condition.
- Large woody debris recruitment and overall pool frequency in this AU has been diminished.
- Recruitment of LWD has been reduced in the 1970-fire area (Fox Creek to Box Canyon) as well as the 1994 fires due to past clearing/post-fire activities.

- Recruitment downstream of Fox Creek is limited, however increases are occurring due to blow-down of dead trees, and pool habitat below Fox Creek is recovering.
- Box Canyon also restricts the through-movement of LWD, thus limiting recruitment below this area.

Fish Passage

- Fish passage throughout the mainstem of this Assessment Unit is at the historic reference condition.
- Passage in several tributary streams is hindered or blocked, primarily for juvenile life stages.
- The amount of habitat upstream of potential problematic tributary culvert barriers is limited.

Harassment

- Reduced hiding cover and increased recreational use of the river has increased the harassment of adult salmonids.

Food

- Carcass availability and nutrient supply for macro invertebrate production has been reduced, thereby reducing the available food source for all native fish species in this area.

Upper Entiat River Assessment Unit

Key Findings:

Water Quality

- Water quality is at pristine condition.

Flow

- Flows are at or near the historic reference condition.

Riparian Conditions

- Riparian and floodplain attributes are stable and considered to be at or near the historic reference condition.
- Some localized compaction and disturbance of riparian vegetation is noted due primarily to trails/recreation, although these are minor at the watershed scale.

Habitat diversity, quantity, and channel stability

- In-channel attributes are considered to be at or near historic reference condition.
- Beaver were trapped from this area long ago and some channel modifications from historic are likely.

Fish Passage

- There are no man-made barriers to fish passage in this Assessment Unit.

Introduced Species

- Brook trout have been introduced and remain in this assessment unit.
- Exogenous rainbow trout are also established.

Mad River Assessment Unit

Key Findings

General Watershed Conditions

- Watershed attributes are considered to be in generally good condition.
- Relatively high human alterations have degraded conditions in the Tillicum watershed and lower Mad River.
- Road densities in the Tillicum Creek watershed are high and may contribute to modest alteration of flow timing and runoff patterns.
- The upper portions of the Mad River are considered to be at or near historical conditions.

Temperature

- Water temperature in the lower Mad River exceeds state water quality standards from July through September.
- The Mad River is minimally affected by direct management of riparian and valley bottom vegetation from RM 4 to the headwaters (nearly 20 miles).
- Water temperatures are believed to be at or near the historic reference condition, although there may be some elevation of this Assessment Unit during low flow years due to past wild fires in riparian areas.

Sediment

- Sediment monitoring over the last 11 years indicates that sediment loads in the lower Mad River (RM 1.3) average 16.9% composition (<1.0 mm).
- Measurements indicate that sediment rates are moderately variable but in a long-term stable and decreasing trend.

Flow

- Flow conditions for the Mad River Assessment Unit are at or near the historic reference condition.
- Past logging and roading may have increased peak flows slightly in the Tillicum Creek watershed.

Riparian Conditions

- Riparian attributes and floodplain function is generally in fair to good condition in this Assessment Unit.
- Some residential development and agricultural land use has degraded riparian vegetation along the stream, and the County road confines the stream channel in the lower 2-3 miles of the Mad River.

Habitat diversity, quantity, and channel stability

- In-channel attributes have been reduced for salmonid rearing and holding in various locations within the Assessment Unit.
- A reduction in large wood and pool habitat is noted, although the trend in LWD recruitment to the Mad River and the creation of pool habitat is increasing.
- Channel confinement in the lower Mad River as a result of the County road has accelerated erosion, degraded habitat diversity and reduced the amount of useable habitat for the focal species.
- Tillicum Creek experiences embeddedness due to sediment deposition associated with higher road densities.

Fish Passage

- Construction of recreational dams/swimming holes that have the potential to block passage of focal species are an ongoing issue of concern in the lower Mad River.
- Two potential barriers to steelhead passage exist within ¼ mile of one another in Tillicum Creek near RM 2.
- A partial barrier exists slightly upstream of the upper barrier.

Ecologic

- Many ecologic attributes remain intact from the historic reference condition.
- The confluence of Cougar Creek and Mad River is known to be a critical area for bull trout spawning and rearing.
- Headwaters of the Mad River are in natural conditions and are highly functioning habitats for cutthroat.

Food

- Reduced input from carcasses and nutrients may have decreased the food base for native fish species.

6.4.3 Hypotheses Statements

Hypothesis statements are based on the key findings and address the condition and ecological interrelationships within the subbasin.

Subbasin Level

Water Quality

Decreasing elevated summer water temperatures to a maximum of 16 °C through out the Entiat subbasin will increase survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the following life stages: spawning, incubation, emergence, and rearing.

Water Quantity

Maintaining the current flow regime throughout the Entiat Subbasin will support and maintain an increase in survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the following life stages: spawning, incubation, emergence, rearing, and pre-spawn holding.

Lower And Middle Entiat

Water Quality

Reducing point source and/or non-point source pollution in the Lower and Middle reaches will increase survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the following life stages: spawning, incubation, emergence, rearing, and pre-spawn holding.

Riparian Floodplain

Increasing riparian shade will decrease instream temperatures thus increasing survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the Lower and Middle Entiat for the following life stages: spawning, incubation, emergence, rearing, and pre-spawn holding

Contaminants

Maintaining or lowering contaminant levels within the Lower and Middle Entiat to at or below Clean Water Act standards will prevent 303d listings and increase the health and survival of all focal species using the areas.

In-channel Habitat

Increase channel complexity and diversity will increase survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the Lower and Middle Entiat for the following life stages: spawning, incubation, emergence, rearing, and pre-spawn holding.

Sediment

Maintaining or reducing sediment loads will increase survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the Lower and Middle Entiat for the following life stages: spawning, incubation, emergence, rearing, and pre-spawn holding.

Nutrients

Increasing nutrient loads will increase survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the Lower and Middle Entiat for the following life stages: spawning, incubation, emergence, rearing, and pre-spawn holding

Harassment

Reduction of harassment will increase survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the Lower and Middle Entiat for the following life stages: spawning and pre-spawn holding.

Barriers

Providing passage to native salmonids will increase survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the Lower and Middle Entiat for the following life stages: spawning, incubation, emergence, rearing, and pre-spawn holding.

Lower and Middle Entiat, and Mad River

Riparian Floodplain

Improving or restoring riparian floodplain will increase floodplain function and overall health within the Lower and Middle Entiat, and the Mad River.

In-channel Habitat

Increase channel complexity and diversity will increase habitat capacity and quality for all species and life stages that inhabit this area.

Harassment

Reduction of harassment will increase survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the Lower and Middle Entiat, and the Mad River, for the following life stages: spawning and pre-spawn holding.

Middle And Upper Entiat

Exotic Species

Reduction in exotic species will increase survival of steelhead, bull trout and westslope cutthroat trout in the Middle and Upper Entiat for the following life stages: spawning, incubation, emergence, rearing, and pre-spawn holding.

General Habitat

Maintaining current habitat conditions will increase the probability of success for programs initiated in other parts of the subbasin to increase productivity of focal species.

6.4.4 Reference Conditions

Reference conditions discuss in general terms the historic, current, and desired future health of focal species populations within the subbasin.

Abundance and productivity

Focal species within the Entiat Basin are believed to be at abundance levels less than they were historically. While no estimates of historic abundance are known, harvest in the lower Columbia River in the middle part of the 19th century and habitat degradation within the Entiat River (including an impassable dam constructed near its mouth), all reduced the abundance of anadromous and other migratory (e.g., fluvial bull trout) species.

Chapman (1986) stated that large runs of chinook and sockeye, and lesser runs of coho, steelhead and chum historically returned to the Columbia River. Based on the peak commercial catch of fish in the lower Columbia River and other factors, such as habitat capacity, he estimated that approximately 588,000 spring chinook, 554,000 steelhead, 3.7 million summer chinook, (for the entire Columbia Basin) was the best estimate of pre-development run sizes. Runs of summer/fall Chinook, sockeye, coho, spring Chinook, and steelhead were relatively abundant in upper Columbia River tributary streams prior to the extensive resource exploitation in the 1860s. By the 1880s, the expanding salmon canning industry and the rapid growth of the commercial fisheries in the lower Columbia River had heavily depleted the mid and upper Columbia River spring and summer chinook runs (McDonald 1895), and eventually steelhead, sockeye and coho (Mullan 1984, 1986, 1987; Mullan et al. 1992). The full extent of depletion in upper Columbia River salmonid runs is difficult to quantify because of limited historical records, but the runs had been decimated by the 1930s (Craig and Suomela 1941). Many factors including construction of impassable mill and power dams, un-screened irrigation intakes, poor logging and mining practices, overgrazing (Fish and Hanavan 1948; Bryant and Parkhurst 1950; Chapman et al. 1982), and private development of the subbasins, in combination with intensive fishing, all contributed to the decline in abundance of Upper Columbia basin salmonids.

Spring Chinook

Spring chinook counting at Rock Island Dam began in 1935. Numbers (adults and jacks) in the period 1935-39 averaged just over 2,000 fish. Average counts fluctuated on a decadal average from the 1940s to 1990s from just over 3,200 (1940s) to over 14,400 (1980s), with recent counts (2000-2002) averaging almost 29,000. The long-term average of spring chinook passing Rock Island Dam is just over 8,900. Counts at Rock Island Dam have been heavily influenced since the 1980s by Leavenworth NFH returns.

Redd counts in the Entiat River basin have been conducted since 1962. Decadal averages are 205, 143, 89, 33, and 81 between 1962 and 2002, with a long term average over the spanning years of 110.

For the Entiat River, Ford et al. (2001) recommended an interim recovery level of 500 spawners per year. The historic redd counts suggest an escapement ranging from 2 to 845, and has averaged 215 since 1962.

Current productivity is affected by loss, or degradation of habitat in spawning and rearing areas, increased downstream mortality through the mainstem Columbia River, ocean conditions, and other abiotic factors (drought, etc.).

Mullan et al. (1992) postulated that current production may not be greatly different than historic for spring chinook. Caveats to this postulate are that native coho are extinct, production comes at a higher cost in terms of smolt survival through the mainstem corridor, and that harvest is drastically reduced (e.g., over 80% in the lower Columbia River in the late 1930s, early 1940s). However, recent estimates of natural replacement rates for spring chinook suggest that they were not replacing themselves in most years until the broods of the late 1990s.

Steelhead

Steelhead counts began at Rock Island Dam in 1933, and annual counts averaged 2,800 between 1933 and 1939 (these numbers do not reflect large fisheries in the lower river that took place at that time, estimated by Mullan et al. (1992) as greater than 60%). Average decadal numbers changed little in the 1940s and 1950s (2,600 and 3,700, respectively). Large hatchery releases began in the 1960s, and the average counts increased to 6,700. In the 1970s, counts averaged 5,700 and 16,500 in 1980s (record count of about 32,000 in 1985). In the 1990s, counts decreased, following a similar trend as chinook, to 7,100, while, similar to chinook, they have increased substantially so far in the 2000s, with an average of over 18,000 (a high of 28,600 in 2001).

Beginning in 1997 (no survey was conducted in 1998), the USFS has been conducting limited spawning ground surveys for steelhead in the Mad River (Archibald 2003). The area covered has increased from the first 3 miles of the Mad River to up to 10 miles (currently the first 7 miles) of the Mad River. Roaring Creek has been surveyed too, but not the mainstem Entiat River. The number of “definite” redds has ranged from 0 (1999) to 38 (2003), averaging 13. Beginning in 2003, the USFWS began counting redds in the Entiat River from approximately RM 2-28. Eighty redds were found in the first year (K. Terrell, personal communication to C. Peven, May 2004).

Ford et al. (2001) recommended interim recovery levels of about 500 naturally produced spawners for the Entiat, using similar criteria that were used for spring chinook.

Current productivity is affected by loss, or degradation of habitat in spawning and rearing areas, increased downstream mortality through the mainstem Columbia River, ocean conditions, and other abiotic factors (drought, etc.).

Mullan et al. (1992) postulated that current production may not be greatly different than historic for steelhead. Caveats to this postulate are that native coho are extinct, production comes at a higher cost in terms of smolt survival through the mainstem corridor, and that harvest is drastically reduced. However, recent estimates of natural replacement rates for steelhead suggest that they are not replacing themselves in most years until the broods of the late 1990s.

Late-run chinook

Late-run chinook did not historically spawn in the Entiat River (Craig and Suomela 1941; Mullan 1987).

Decadal averages of summer/fall chinook escapements at Rock Island Dam from 1933 through 2002 show a rising trend. Harvest rates in the 1930s and 1940s were very high in the lower river fisheries, and no doubt had a large impact on the escapement at Rock Island (Mullan 1987). In 1951, when harvest rates in zones 1-6 (lower Columbia River) were reduced, numbers increased dramatically. Between the 1930s (starting in 1933) and 1960s (excluding 1968 and 1969) , total (adults and jacks) decadal average numbers of summer/fall chinook rose from just over 7,000 to almost 28,000. Numbers remained high in the 1970s until the mid-1980s, when they declined through the 1990s and have shown a sharp increase in the 2000s.

Redd counts have been conducted in the Entiat River since 1957. Counts ranged from 0-55 between 1957 and 1991 (Peven 1992). Between 1994 and 2002, Hamstreet and Carie (2003) estimated the number of summer/fall chinook redds ranging between 15-218, averaging 75.

Current productivity is affected by loss, or degradation of habitat in spawning and rearing areas, increased downstream mortality through the mainstem Columbia River, ocean conditions, and other abiotic factors (drought, etc.).

Coho

An estimated run size of 9,000-13,000 coho salmon historically spawned in the Entiat River (Mullan 1984). Currently the indigenous stock of coho salmon is extripated from the Entiat River and in need of restoration. Successful reintroduction efforts in the Wenatchee and Methow Rivers will likely be expanded to include the Entiat River in the near future. Similar reintroducion methods will also be used. Mid-Columbia coho reintroduction (Wenatchee, Entiat, and Methow) is identified as a priority in the *Wy-Kan-Ush-Mi-Wa-Kish-Wit* document (Tribal Restoration Plan) and by the four Columbia River Treaty Tribes and has been affirmed as a priority by the Northwest Power Planning Council.

The historic productivity of coho salmon within the Entiat Basin is not known, however it is reasonable to assume that it was higher than can currently be expected for reintroduced coho based on habitat degradation in spawning and rearing areas.

Bull trout

Historic productivity of bull trout within the Entiat Basin is not known. However, it is reasonable to assume that it was higher, based on habitat degradation and management practices (harvest). Current productivity appears to be improving based on redd counts and other factors.

Bull trout redd surveys have been conducted by the USFS in the Entiat River Basin since 1989, primarily in the Mad River. Since 1989, the number of redds observed has averaged 24, and has increased, primarily since 1997. Archibald and Johnson (2002) attribute the increase in bull trout redds in the Mad River to the closure of bull trout fishing in 1992 and the closure to all fishing (from the mouth to Jimmy Creek) since 1995. Bull trout are also known to spawn in the mainstem Entiat but it is uncertain to what degree.

Westslope cutthroat trout

Historic productivity of westslope cutthroat trout within the Entiat Basin is not known. However, it is reasonable to assume that it was higher, based on habitat degradation and management practices (hatchery plants). There are no known estimates of current abundance within the Entiat River Basin.

Summary

Below is a summary of the some key indicators relating to population health of the focal species, looking at presumed historic, current, potential, and future (if no action was taken) status.

Table 24. Key indicators to population health of focal specieis in the Entiat subbasin

	Distribution	**Abundance**	**Productivity**	**Diversity**
Spring chinook				
Historic	High	Moderate	Moderate	Moderate
Current	Mod-high	Low	Low-mod.	Low-mod.
Potential	High	Moderate	Moderate	Moderate
Future w/ no action	Mod-high	Low-mod.	Low-mod.	Low-mod.
Steelhead				
Historic	High	Low-moderate	Moderate	High
Current	Mod-high	Low	Low	Moderate
Potential	High	Low-moderate	Low-moderate	Mod-high
Future w/ no action	Mod-high	Low	Low	Moderate
Sum/fall chin.				
Historic	None	none	none	none
Current	Moderate	Low	low	low
Potential	Moderate	Low	low	low
Future w/ no action	Moderate	Low	Low	Low
Coho				
Historic	High	Moderate	High	High
Current	None-Low	None-Low	None-Low	Low
Potential	Moderate	Moderate	Moderate	Moderate
Future w/ no Action*	None-Low	None-Low	None-Low	Low
*No action includes no active coho reintroduction to date				
Bull trout				
Historic	High	Low-moderate	Moderate	High
Current	Mod.-high	Low	Low-moderate	Mod.-high

	Distribution	Abundance	Productivity	Diversity
Potential	High	Low-moderate	Moderate	High
Future w/ no action	Mod.-high	Low	Low-moderate	Mod.-high
Westlope cutthroat trout				
Historic	Low-moderate	Low	Moderate	High
Current	Low-moderate	Low	Low-moderate	Mod.-high
Potential	Low-moderate	Low	Moderate	High
Future w/ no action	Low-moderate	Low	Low-moderate	Mod.-high

Note: Low = < 500 spawners; Moderate= 500-1,000; High= > 1,000

6.4.5 Near Term Opportunities

Because coho salmon spawn and rear in habitats different than the other focal species, the reintroduction of coho salmon represents a tremendous opportunity to increase natural salmonid production and biodiversity in the Entiat River.

Current properly functioning habitat occurs in the mid- to upper portions of the Entiat River AU and Mad River AU. These areas hold the best spawning and rearing habitat for bull trout, spring chinook, steelhead, and westslope cutthroat trout.

Access to portions of the upper Entiat and Mad rivers are blocked by natural migration barriers (falls) (Figure 17). One postulate is that a thermal blockage may occur for migrating adult summer/fall Chinook in the lower Entiat River, but this has not been investigated yet. Some culverts within some tributaries inhibit juvenile fish from reaching rearing areas.

One of the main limiting factors for focal species in the Entiat River is the availability of off channel habitat in the lower assessment unit. Because of various land use practices, off channel habitat has been limited within this reach. Downstream migrant and potentially some adult migrants would benefit if more of this habitat was created for hydrologic refugia and increased trophic opportunities.

Near term opportunities are a list of potential restoration or enhancement projects that have been identified as having relatively high benefit to subbasin planning goals and objectives. This list is not intended to be comprehensive for salmon recovery, nor is it intended to provide the basis for prioritization. These projects can be accomplished within a 10-year time frame and would significantly contribute towards achievement of long-term objectives and desired future conditions.

These near-term opportunities were derived from and/or are consistent with the following documents:

- Entiat Water Resources Inventory Area (WRIA) Management Plan (Final Draft; January 2004)

- Federal Watershed Assessment for the Entiat (Watershed Restoration Projects, April 1996)
- Entiat Comprehensive Resource Management Plan (Entiat River Inventory and Analysis, NRSC Stream Team Report, 1/6/98)
- Entiat Ecosystem Diagnosis and Treatment Analysis (Final Report, Mobrand Biometrics, Inc. February 2003)
- Tribal Recovery Plan; Wy-Kan-Ush-Mi Wa-Kish-Wit, (Spirit of the Salmon)

The documents above are incorporated by reference into these near-term opportunities.

The priorities for development of in-channel and floodplain restoration projects on all ownerships in the subbasin will be better defined over the next year as the Entiat Planning Unit finalizes the Entiat WRIA Management Plan under the Washington State Watershed Planning Act. Over the last several years, the Planning Unit has concentrated its support to key demonstration projects (e.g., habitat diversification in the lower Entiat). Because habitat conditions are most degraded in the Lower assessment unit, and because there are a number of opportunities for habitat improvements to benefit focal species, projects in these areas will remain as high priority within the subbasin.

The priorities for restoration projects on National Forest System (NFS) lands are reflected in Table 5.1 (Management Strategy Priorities) in Version 2.0 of the Federal Watershed Assessment for the Entiat Analysis Area. On NFS lands, emphasis will be placed on the following categories of projects: (a) burned area recovery; (b) projects that move landscape toward a more resilient condition that is better able to handle perturbations or withstand wildfire and insect/disease epidemics; and (c) access management projects designed to improve surface water control, reduce accelerated erosion/sedimentation, increase wildlife security and reduce maintenance costs.

The following summarizes key projects that are anticipated to be implemented, or substantial progress towards implementation will have been accomplished within the next 10-years:

Subbasin-Wide Opportunities

- The extent of harassment and poaching on salmonids is unknown, especially as pre-spawning adults are holding and are vulnerable. Develop and implement a long-term and sustained public education campaign and increase enforcement activities to reduce harassment and poaching of salmonids.
- Complete a comprehensive evaluation of sediment delivery into streams from the road system. Prioritize management actions and implement actions to reduce or eliminate sediment delivery for all high priority roads. Complete long-term management plan which is coordinated between all parties with authority and responsibility for the road system and the public.
- Macro-invertebrate sampling within the Entiat subbasin has been infrequent and conducted without a larger-scale strategy. Complete a long-term macro-invertebrate monitoring strategy and implement all high priority components of this strategy.

- It is generally assumed that significant biologic (primary) productivity has been lost in the mainstem and tributary streams of the Entiat River due to a decrease of salmonid carcasses left after spawning. Resource managers should evaluate the best means to replenish these lost nutrients into the stream system and implement pilot projects to determine the potential benefits to salmonids and the stream ecology.
- Evaluate bio-accumulation of toxic materials within the flesh of indicator fish species to determine the extent that these materials are entering into the ecologic and human food chain.
- Evaluate existing and potential salmonid carrying capacity in all of the Assessment Units to increase our knowledge about this areas potential contribution towards salmon recovery.
- Continue to use forward looking infrared (FLIR) technology to identify areas where important differences in water temperature may signal important micro-refugia for winter and summer rearing. FLIR information is presently available for summer months. FLIR information should be collected during winter months.

Opportunities per Focal Species

Bull trout and westslope cutthroat trout:

Populations and distribution remain widely unknown throughout the subbasin. Evaluations to better understand population characteristics of these species should continue, including but not limited to genetic analysis, abundance estimates, age distribution and spatial distribution.

Spring Chinook

The current operation of the Entiat National Fish Hatchery is to separate the production of hatchery fish from the production of the naturally reproducing population within the subbasin. The fishery co-managers, within the U.S. v. Oregon jurisdictional forum and in coordination with other regional fishery programs and obligations should begin evaluating the feasibility, suitability and implications of re-directing Program objectives to integrate the hatchery production with the naturally producing population. Implementation of this change in production strategy will occur through a collaborative effort by all stakeholders.

Late-run chinook

Any projects that would increase the off channel habitat in the lower river, decrease late summer temperature would be beneficial to late-run Chinook salmon. Projects such as the proposed “bridge to bridge,” (see below) in-channel structural diversity, and other off-channel work should be implemented as soon as possible.

Steelhead

Continue on-going efforts to count redds and determine spawning distribution. Initiate a comprehensive effort to evaluate distribution and habitat use for various life history stages.

Opportunities for Other Species

Coho

The Yakama Nation is currently in the feasibility phase for re-introducing natural coho salmon in the Wenatchee and Methow subbasins. A similar effort is currently being discussed between fishery managers for other areas within the Columbia Cascade Province, including specifically the Entiat Subbasin. The fishery co-managers, within the U.S. v. Oregon jurisdictional forum and in coordination with other regional fishery programs and obligations will be evaluating the feasibility, suitability and implications of re-directing the Entiat National Fish Hatchery Program objectives (and/or other hatchery facilities) to integrate production of coho salmon into the Entiat subbasin. Implementation of this change in production strategy will occur through a collaborative effort by all stakeholders.

Reintroduction of coho will substantially increase anadromous salmonid production in the Entat subbasin.

Pacific Lamprey

Very little information about this species is available for the Entiat Subbasin. Evaluations should begin that identifies species presence, habitat preferences and habitat availability. Evaluations addressing artificial propagation of this species should be coordinated with a larger and similar effort throughout the Columbia Cascade Province.

Opportunities for Habitat Needs

Entiat River – Instream Habitat Diversification:

Instream structure placement (rock cross vane structures, large woody debris, etc.) throughout the lower 20 river miles of the mainstem Entiat River. Implement Alternative 4 (Entiat WRIA Management Plan) for pool development downstream of Potato Creek and for streambank protection above Potato Creek. Multiple ownerships are involved. See NRCS Stream Team Report for details (January, 1998).

Entiat River Corridor - Riparian Planting:

Establish approximately 40,000 lineal feet of riparian planting from the mouth of the river through RM 20. Primary emphasis on maintenance of existing, native riparian vegetation, with secondary emphasis placed on planting. Multiple ownerships are involved. See NRCS Stream Team Report for details (January, 1998).

Entiat River "Bridge to Bridge" Fish Habitat Restoration:

Project proposal includes components of projects noted above, but emphasizes development and restoration of side-channel habitat. Multiple ownerships are involved.

Off-Channel Habitat:

Development of a pond (with structural diversity) and outlet stream (600' long) to create new off-channel, rearing/refuge habitat for salmonids. This project proposal also includes bio-engineered bank stabilization work along the Entiat River at this site.

Fish Screening of Diversions and Pumps:

Installation, upgrade and/or maintenance of fish screens on water withdrawal facilities in the lower subbasin. See the 1997 WDFW Inventory of Entiat River screening needs for identification on which screens need upgrades or maintenance. Inventory update and additional screen installation work have been proposed by WDFW for Bonneville Power Administration FY2003 grant funding.

Fish Passage Maintenance and Improvement:

Various projects involving the restoration of aquatic connectivity due to problems road culverts in the Subbasin. Refer to County-sponsored culvert/fish passage inventory.

Alternative Five – Ecosystem Diagnosis and Treatment Analysis:

Five alternative restoration scenarios were evaluated for the Entiat Planning Unit using the Ecosystem Diagnosis and Treatment methodology. These alternative scenarios were primarily based upon recommendations advanced by the Entiat Comprehensive Resources Management Plan (1998). The Entiat Planning Unit has adopted to employ the intent of Alternative Five as described in Appendix XXX (Entiat EDT Watershed Analysis February 2003). These recommendations are incorporate into this subbasin plan and described in Chapter 9.4 of the Entiat Watershed Resources Inventory Area Management Plan (Final Draft; January, 2004)

Irrigation System Improvements:

A variety of conveyance and conservations improvements on the major irrigation ditches in the subbasin are recommended. The combination of the Knapp-Wham and Hannan-Detweiler systems is proposed for preliminary design via Bureau of Reclamation funding. This project would involve upgrade and extension of the Knapp-Wham system, well installations and closure of the Hannan-Detweiler ditch. The NRCS is evaluating additional opportunities for irrigation delivery and application systems technology improvements.

On-Farm Resource Management Improvements:

Ongoing planning and application of conservation practices via the NRCS's Environmental Quality Incentive Program (EQIP), Wildlife Habitat Incentive Program (WHIP), and other programs that provide cost-share opportunities that make the implementation of conservation practices economically viable, will continue. Irrigation Water Management (IWM), Nutrient Management, and Pest Management may be used to address water quality and quantity concerns.

Wetlands Improvements:

Projects targeted at maintenance or enhancement of the function of wetland areas in the subbasin, especially in the lower river corridor where sites have been modified by flood control work.

Entiaqua River Park and Outdoor Learning Center:

Project involves development of a park/learning center facility in concert with restoration of the riparian area at the mouth of the Entiat. See Entiaqua River Park Briefing Paper for details on proposed park and related riparian restoration work envisioned at this time. Chelan PUD, City of Entiat and Chelan County lands and/or rights–of-way are involved.

Livestock Access Management:

A few locations in the lower river corridor need fencing and off-stream water development to restrict stock access to riparian areas and stream banks.

Entiat Valley Road Rehabilitation Projects- Chelan County and USFS:

- Road relocation and riparian/stream bank restoration at MP 16.3 (CC ROW)
- Fill slope stabilization at MP 17.2 (upper end of Thomas property; CC ROW)
- Fill slope stabilization at site just within NF boundary ("wood duck site")
- Possible correction of Valley Road-River overflow concerns at several other sites
- Improvements to stream crossings at Mud and Potato Creeks
- Other Valley Road sites to be identified in next version of project list

Improvement of Road Management Practices on State and Private Lands:

Cooperative effort to improve road maintenance and management practices on roads in the lower Entiat River corridor to improve surface water control, reduce sedimentation and improve/maintain fish passage. Projects include improved management of lower Mud Creek and lower Tyee roads; crossing replacements in Stormy Creek, etc.

Water Use and Instream Flows:

The Entiat Planning Unit is on course to establish instream flows in the next couple years for portions of the Entiat subbasin. Associated with establishing instream flows the Entiat Planning Unit has identified many water conservation and administrative recommendations designed to benefit human and natural resource needs. Incorporate by reference management recommendations identified in Chapter 9.3 of the Entiat Watershed Resources Inventory Area Management Plan (Final Draft; January, 2004).

Water Quality:

The Entiat Planning Unit has recently approved a suite of actions that continue to monitor and improve water quality throughout the Entiat subbasin. These recommendations are incorporate into this subbasin plan and described in Chapter 9.5 of the Entiat Watershed Resources Inventory Area Management Plan (Final Draft; January, 2004).

Ecosystem Restoration Priorities on National Forest System (NFS) Lands

The overall strategy for ecosystem restoration/maintenance on NFS lands in the Entiat Subbasin is currently being revised (update of approach in Version 2.0 of the Federal Watershed Assessment). This strategy will focus on restoring forest ecosystem pattern, composition and process within specified geographic areas within the Entiat Subbasin. Many of these projects will involve cooperative agreements with private and other non-federal land management actions. Many projects have been identified addressing vegetation management, road management, campground and dispersed recreation improvements, and fish and wildlife habitat enhancements. These projects are summarized in Appendix XXX of this document.

Terrestrial

Focal species were grouped by the habitat type that they live in. Therefore, the habitat type and the focal species will be grouped in the interpretation and synthesis.

Key findings and hypothesis

Habitat: Ponderosa pine

Focal species: white-headed woodpecker, flammulated owl, pygmy nuthatch

Key findings

- Timber harvesting has reduced the amount of old growth forest and associated large diameter trees and snags.
- Urban and residential development has contributed to loss and degradation of properly functioning ecosystems.
- Fire suppression/exclusion has contributed towards habitat degradation, particularly declines in characteristic herbaceous and shrub understory from increased density of small shade-tolerant trees. High risk of loss of remaining ponderosa pine overstories from stand-replacing fires due to high fuel loads in densely stocked understories.
- Overgrazing has resulted in lack of recruitment of sapling trees, particularly pines.
- Invasion of exotic plants has altered understory conditions and increased fuel loads.
- Fragmentation of remaining tracts has negatively impacted species with large area requirements.
- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and may be subject to high levels of human disturbance.

Working hypothesis

1. Habitat has been lost due to timber harvest, fire reduction (and subsequent intensive wildfires), mixed forest encroachment, and development.

2. Habitat diversity and function has been lost from invasion of exotic vegetation and grazing.

3. Loss of habitat and habitat diversity/function has resulted in extirpation or reduction of ponderosa pine obligate species.

Habitat: Shrub-steppe

Focal species: Brewer's sparrow, mule deer

Key findings

- Degradation of habitat from intensive grazing and invasion of exotic plant species.
- Fire management, either suppression or over-use, and wildfires.
- Invasion and seeding of crested wheatgrass and other introduced plant species which reduces wildlife habitat quality and/or availability.
- Loss and reduction of cryptogamic crusts, which help maintain the ecological integrity of shrub-steppe/grassland communities.
- Human disturbance during breeding/nesting season, parasitism.

Working hypothesis

1. Reduction of habitat diversity/function has occurred from invasion of exotic vegetation, wildfires, and grazing.
2. Habitat loss and fragmentation, coupled with poor quality of existing habitat has resulted in the extirpation or reduction of shrub-steppe obligate species.

Habitat: Eastside (Interior) Riparian Wetlands

Focal species: beaver, red-eyed vireo, yellow-breasted chat

Key findings

- Habitat degradation from livestock overgrazing which can widen channels, raise water temperatures, reduce understory cover, etc.
- Hostile landscapes, particularly those in proximity to agricultural and residential areas, may have high density of nest parasites (brown-headed cowbird), exotic nest competitors (European starling), and domestic predators (cats), and be subject to high levels of human disturbance.

Working hypothesis

1. Loss of habitat diversity/function has resulted from invasion of exotic vegetation and grazing.
2. Habitat loss and fragmentation, coupled with poor quality of existing habitat has resulted in the extirpation or reduction of riparian obligate species.

7 Management Plan

7.1 Introduction

The information below will be used by subbasin planners and state salmon recovery personnel to aid in the conservation and restoration of the important habitat that will aid in the recovery of the focal species.

The management plan is made up of five components: the vision for the subbasin; biological objectives; strategies; research, monitoring and evaluation; and ESA and CWA requirements. Since the biological objectives are linked to the working hypotheses, we have inserted them here also for better clarity.

Aquatic and terrestrial portions of the management plan were completed independently.

7.2 Vision for the Plan

The vision for the Entiat subbasin plan iso voluntarily bring people together in a collaborative setting to improve communication, reduce conflicts, address problems, reach consensus and implement actions to improve coordinated natural resource management on private and public lands in the Entiat subbasin. The vision is to implement the locally developed, science based subbasin management plan using watershed specific information ultimately leading towards compliance with the federal Endangered Species Act (ESA) and Clean Water Act (CWA). End products will reflect a balance between existing natural resources and human uses and will capitalize on opportunities to improve these values.

Specific goals to move us forward towards this vision under the Watershed Planning Act are as follows:

- Optimize quantity and quality of water to achieve a balance between natural resources and human use both current and projected
- Provide for coexistence of people, fish and wildlife while sustaining lifestyles through planned community growth, and maintaining and/or improving habitats
- No avoidable human-caused mortality of state and federal threatened, endangered and candidate species

Develop and implement an adaptive action plan to address priority issues, emphasizing local customs, culture and economic stability in balance with natural resources. All actions will comply with existing laws and regulations. However, changes to existing laws and regulations will be recommended as needed to attain our common vision and avoid one-size-fits-all solutions.

Recognizing the significance of the roles of limiting factors outside of the watershed and natural events within the watershed, the long-term goal is to have the Entiat River's existing and future habitats contribute to the recovery of listed species and to eventually provide harvestable and sustainable populations of fishes and other aquatic resources.

Since 1993, landowner members of the CRMP Group/EWPU have always insisted that good science be applied to the collection and interpretation of information for all resource elements of concern. They hope that through the continued use of good science, the mission and goals of the group will be met, and with landowner cooperation during implementation, regulating agencies may not find it necessary to apply one-size-fits-all regulations to achieve their management objectives for the Entiat subbasin (CCCD 2004).

7.3 Purpose and Scope

The management plan integrates the vision for the Entiat subbasin with the assessment and inventory. The vision and goals were crafted by the Entiat Planning Unit and are incorporated into the Entiat subbasin plan. The vision and goals also drive for the selection of objectives and strategies for restoration of fish and wildlife habitat and populations, which form the bulk of the management plan.

The scope of the management plan is somewhat narrower than the scope of the assessment or the inventory. The assessment and inventory are designed to guide restoration and management actions by many parties under their own authorities in the course of ongoing efforts to protect and enhance the fish and wildlife populations and the aquatic and terrestrial ecosystems that exist within the Entiat subbasin. The management plan is based on the assessment and inventory, but is specifically designed to act as a draft amendment to the Columbia Basin Fish and Wildlife Program, and to be reviewed and approved by the Northwest Power and Conservation Council (NPCC).

The management plan describes the most effective ways that NPCC and Bonneville Power Administration (BPA) can use funding resources to meet obligations in the Entiat subbasin for protection and mitigation of resources that have been affected by the construction and operation of the Federal Columbia River Power System (FCRPS). As such, the management plan is non-regulatory in nature and contingent on BPA ratepayer funds to construct or improve existing infrastructure, acquire land or protective easements as a means of habitat protection, fund personnel to improve management of natural resources, monitor and research the relationships between management actions and the health of the resource, and fund other actions that protect or restore the health of natural resources that have been negatively impacted by the FCRPS.

7.3.1 Overarching Principles

The Entiat has a long history of citizen participation in resource management efforts. The Planning Unit recognizes the close connection between community well-being and watershed conditions, and as a result a set of basic principles regarding the past, present and future of Subbasin became clear during this planning process. The Planning Unit therefore acknowledges the following overarching principles:

Continued community participation and involvement with the Entiat Watershed Planning Unit is necessary to ensure its future success and achievement of the group’s vision and goals

Future projects proposed in the subbasin need to be communicated to and coordinated with the Chelan County Conservation District and Entiat Watershed Planning Unit in order to reduce duplication of effort and assure compatibility with this strategic plan

Monitoring and continual feedback are key to the design of future projects and tracking progress to wards the achievement of desired results

Surface and ground water in the subbasin have a high degree of connectivity; therefore surface and ground water in the watershed should be treated as one source for all water quality, quantity, habitat and instream flow actions

7.4 Subbasin Planning Guidelines

The natural environment including its fish and wildlife resources is society's common cultural heritage. The underlying premise of the Entiat Planning Unit's *Mission* and *Goals* is to prepare and implement a balanced plan of action that plays a key role in the long-term sustainability of society's common cultural heritage within the Entiat subbasin.

The quality of water, a near natural timing, and quantity of water flow (normative hydrograph) are principle indicators of a healthy river ecosystem. These indicators must be improved and monitored to measure the progress of the subbasin plan.

The Entiat subbasin management plan enhances Native Americans' continued exercise of treaty reserved and aboriginal rights for religious, subsistence, commercial, and recreational use of cultural (natural) resources.

The Entiat subbasin management plan is based on voluntary incentives.

The processes of plan preparation, implementation, and amendment, must be open to the public and equitable to all stakeholders.

The costs of plan actions must be estimated in relation to benefits. Alternatives that achieve the highest benefit/cost ratio are preferred. Costs of habitat/species restoration should be mitigated and distributed equitably.

The science, strategies, and art of restoring ecosystems is evolving, hence programs and actions must be monitored and evaluated for effect, and may be altered as necessary.

Balanced sustainable resources management recognizes these basic precepts: a) that the physical and biological environments are functionally interdependent relative to productivity, b) that at any level of function, productivity is finite; c) without actions to restore degraded functions and to protect, avoid, and mitigate impacts to the physical and biological environment, the increasing demands of human population growth would reduce productivity to zero, with unacceptable costs to the cultures and economies of the subbasin.

7.5 Aquatic

7.5.1 Fisheries Biological Objectives

Recovery and maintenance of key populations must achieve two broad objectives:

1. Restore populations to a point where they no longer require the protection of the Endangered Species Act (ESA)

2. Maintain populations at a level that allows meaningful opportunity for tribal and non-tribal hunting and fishing rights.

Achievement of these objectives requires a healthy ecosystem and application of sound management principles. Four parameters form the key to evaluating and measuring the status of a population's health. They are: abundance (population size), population growth rate, population spatial structure and life history diversity. These parameters are reasonable predictors for extinction risks, they reflect general processes that are important to all populations of all species, and they are measurable.

Below is a brief synopsis of the biologic objectives underlying each of these four parameters. This information is derived from the NOAA Fisheries Technical Memorandum NMFS-NWFSC-42 (2000). Although many of the principles established in this work are technically sound, use of NOAA Fisheries concepts in this subbasin plan does not imply adoption of the referenced document. The subbasin plan recognizes the biologic objectives for cutthroat and bull trout contained in the USFWS Draft Bull Trout Recovery Plan, (2004) and incorporates by reference this document and biologic objectives.

Abundance

Populations are large enough to have a high probability of surviving environmental variation of the patterns and magnitudes observed in the past as well as those expected in the future.

Populations have sufficient abundance for compensatory processes to provide resilience to environmental and human caused disturbances.

Populations should be sufficiently large to maintain genetic diversity over a long term.

Populations should be sufficiently abundant to provide important ecological functions throughout its life cycle.

Population Growth Rate

Population natural productivity is sufficient to maintain its abundance above the viable level.

The population that includes naturally spawning hatchery fish exhibits sufficient productivity from naturally produced spawners to maintain population abundance above viability thresholds in the absence of supplemented hatchery production.

Populations exhibit sufficient productivity during fresh water life history stages to maintain abundance above thresholds, even during poor ocean (or other relevant environmental) conditions.

Populations do not exhibit sustained declines in abundance that span multiple generations and affect multiple broodyear cycles.

Populations do not exhibit trends or shifts in traits that portend declines in a population's growth rate.

Population Spatial Structure

Salmonid habitat should not be destroyed faster that is naturally created.

Natural rates of straying among subpopulations should not be substantially increased or decreased by human actions.

Some salmonid habitat should be maintained that appear suitable or marginally suitable, but currently contain no fish.

Key subpopulations (highly productive) should be maintained to support other subpopulations with lower productivity.

Life History Diversity

Human caused changes such as habitat changes, harvest pressures, artificial propagation, and exotic species introduction should not alter variation in traits such as migration timing, age structure, size, fecundity, morphology, behavior, and molecular genetic characteristics.

Natural processes of dispersal should be maintained. Human caused factors should not substantially alter the rate of gene flow among populations.

Natural processes that cause ecologic variation should be maintained.

7.6 Fisheries Habitat Objectives and Desired Future Conditions

7.6.1 Introduction

Habitat objectives are organized in a manner consistent with the information presented in the assessment of the Entiat subbasin plan. The intent is to provide specific and measurable objectives for habitat attributes important to maintain long term viability to native aquatic and riparian dependent species within the subbasin. Resource managers attaining these objectives will provide a baseline for long term environmental desired future conditions. (The following habitat objectives come primarily from "A Framework to Assist in Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Bull Trout Subpopulation watershed Scale" (US Fish and Wildlife Service 1999)).

It is understood that not all environments and habitat are inherently capable of achieving or maintaining these general standards. Human developments will also preclude attainment of these standards in some cases. However, to the extent feasible, the objective of the Entiat subbasin plan is to maintain and improve healthy ecosystems within the Entiat subbasin, via measurable habitat objectives that can be monitored.

7.6.2 Watershed Conditions

Disturbance Regime

Environmental disturbances (wildfire, etc.) are short lived with little or no long term change to the hydrograph. High quality habitats and watershed complexity continue to provide refuge and rearing space for the expected assemblage of organisms, for all life stages and/or multiple life history forms. Natural processes are stable and resilient to significant changes over time.

Road Density/Location

At the watershed scale (6^{th} field hydrologic unit code – HUC) road densities do not exceed one linear mile per square mile. Roads are maintained to provide adequate drainage and to minimize sediment transport. Valley bottom roads are relocated where feasible to minimize the affects to riparian and floodplain habitat, and functional attributes.

Refugia

Landscape scale habitats capable of supporting strong and significant populations are maintained and are well distributed and connected for the expected assemblage of organisms and for all life stages.

Water Quality

Temperature

Water temperatures will be at or near normative conditions throughout the year. Where possible the 7-day average maximum temperature in a stream reach will not exceed 2-5°C during incubation periods; 4-12°C during juvenile rearing periods and 4-9°C during spawning periods. Also, water temperatures do not exceed 15°C in areas usedby adults during migration thereby providing no thermal barriers to movement.

Sediment

Fine sediment (< 0.85mm) measured in spawning and incubation habitat is less than 12% of the total substrate composition. (If surface fines (< 0.6mm) are included, then total substrate composition should not exceed 20%.

Cobble and gravel substrate embedded by fine sediment/materials in juvenile rearing areas does not exceed 20%.

Contaminants and Nutrients

Low levels of chemical contaminants, waste materials (nutrients) from agricultural, industrial and other sources are measured in surface and ground water systems. There are no stream reaches designated as impaired (303d) under the CWA.

Water Quantity

The watershed hydrograph is at or near normative condition (peak flow, base flow and flow timing characteristics) compared to other watersheds of similar size, geology, and geography.

Riparian/Floodplain Condition

Riparian Condition

Riparian areas provide adequate shade, large woody debris (LWD) recruitment, and habitat protection and connectivity in sub watersheds. Riparian areas provide buffers and includes refugia for sensitive aquatic species (>80% intact). Riparian areas maintain at least 50% similarity of riparian vegetation to the potential natural community/composition.

Floodplain Connectivity

Off-channel and side channel areas are frequently (annually) hydrologically linked to main river. High flows that exceed the natural stream bank capacity are allowed to occur to reduce water velocity and energy within the stream channel and to maintain wetland functions, riparian vegetation, and succession.

In-Channel Conditions

A relatively high degree of in-channel structural diversity exists throughout stream reaches where expected. LWD occupies the channel at greater than 20 pieces per mile. LWD pieces must be >12 in. diameter at the small end and at least 35 ft. in length. Also, there is an adequate source of woody debris available within the riparian corridors for both long and short-term LWD recruitment into the stream channel.

Pool Quantity and Quality

In streams that are greater than 9.8 ft. in wetted width at base flow, large pools (those that occupy most of the channel width and are greater than one meter deep) are commonly found in reaches with adult holding, juvenile summer or overwintering rearing.

Pool frequency is known to be variable, typically depending upon the stream width. Pool frequency in a stream reach closely approximates:

Table 25. Pool frequency in the Entiat subbasin

Wetted width (ft)	#pools/mile
0-5	39
5-10	60
10-15	48
15-20	39
20-30	23
30-35	18
35-40	10
40-65	9
65-100	4

Pools have good cover and cool water, and only minor reduction of pool volume by fine sediment

Off-Channel Habitat

Watersheds have many ponds, oxbows, back waters, and other off-channel areas with adequate hiding cover. Side channels provide areas with low hydrologic energy that act as refuge for juvenile fish, especially during high flow events.

Channel Condition/Dynamics

Channel width to depth ratios, as measured for the stream reach, is at or near the expected normative value as described by Rosgen (1996).

Stream bank condition as measured for the stream reach is approximately 90% stable for approximately 80% of the linear stream channel.

Fish Passage

Man-made barriers present in watershed allow upstream and downstream fish passage at all flows. There are no barriers to fish passage within the subbasin.

Ecological

To the extent possible, non-native and non-desirable species are not present or do not have a significant affect through competition or predation on other native or desired species within the watershed.

7.6.3 Recommendations for Management

Strategies, Objectives, and Near-term Opportunities

The following pages summarize recommendations for management strategies, management objectives and near-term opportunities at both the subbasin scale and for each of the individual assessment units. For each assessment unit important information from the assessment and key findings are summarized. For each of the habitat attributes, recommended management strategies are provided that identify general direction for future management emphasis. For each management strategy, one or more management objectives are listed that imply certain types of actions that might be employed to successfully achieve the management strategy. Concluding the recommendations for each assessment unit, near-term opportunities are suggested.

Near term opportunities are a list of evaluations and potential restoration/enhancement projects that have been identified as having relatively high benefit to subbasin planning goals and objectives. This list is not intended to be comprehensive, nor is it intended to provide the basis for prioritization. Rather, these are projects that could be accomplished within a 10-year time frame and would significantly contribute towards achievement of long term objectives and desired future conditions related to salmon recovery. Due to the nature of the landscape and/or the project type, near-term opportunities are likely to be more easily implemented than many other actions. Many other activities should be considered, although development of these projects is expected to be more complex and requiring more time than available within the scope of this planning process.

Lower Entiat River Assessment Unit

Water Quality

Temperature

- Reduce impact of high temperature on incubation, rearing, and migrating adults so it does not exceed the 7 day average maximum within any reach by 2020

Sediment

- Reverse increasing trend and begin moving sediment loads to12% fines (0.85mm) in spawning gravels by 2020
- Decrease substrate embeddedness conditions throughout the Assessment Unit by 2020

Contaminants

- Maintain toxic pesticide and herbicides within regulatory standards and avoid contact of these materials with water
- Reduce or eliminate waste materials from surface and ground waters from failing septic systems and livestock by 2015
- Evaluate the effect of effluent from the Entiat National Fish Hatchery and maintain water quality at or below regulatory standards

Water Quantity

Flow

- Reduce impact, and increase efficiency of water withdrawal during August and September by 2020
- Decrease severity of high flow events by increasing in-channel structural diversity and restoring geofluvial processes by 2025

Riparian Floodplain

Riparian Condition

- Reestablish riparian vegetation corridors and associated stream canopies where they have been denuded to a minimum of 75% of the estimated historic condition, where feasible by 2025. Prioritize efforts in areas where other channel restoration projects occur.
- Increase the number of large trees (site potential tree height) and complex riparian communities that will eventually increase the natural recruitment of LWD by 2025.
- Reduce impacts to riparian areas from development and livestock management within the riparian area by 2015.
- Reduce road density in riparian areas throughout the Assessment Unit by 2025.

Floodplain Condition/Connectivity

- Minimize affects of development on channel migration zones within the riparian and floodplain, and increase stream sinuosity through active restoration when feasible by 2025.
- Increase, or reconnect floodplain (off-channel) habitats, where feasible, by 2025.
- Maintain and enhance wetland complexes, enhance ground water recharge by 2025.
- Remove bank armoring/dikes where applicable and appropriate by 2025.
- Protect/enhance geo-fluvial processes and floodplain function by 2025.

Road Density / Location

- Reduce road density to less than 1 miles/mi2 by 2030.
- Where feasible, relocate roads from the valley bottoms by 2030.

In-Channel

In-channel

- Increase in-stream structural diversity and complexity to provide refuge to juveniles during high flow events by 2020.
- Increase stream bank stability using active and passive restoration techniques, where feasible, by 2015.
- Increase/restore habitat diversity by increasing off-channel habitat, backwaters with cover and low energy refugia by 2025.
- Evaluate the use of irrigation ditches as a means to increase rearing habitat by 2010.

LWD

- Increase LWD to 20 pieces per mile (12”diameter > 35 ft length) and provide adequate sources for future woody debris recruitment in the riparian areas by 2025.

Pool Frequency and Quality:

- Increase quality pool (20 m2 by 1m deep) to an average of 9 pools per mile (Entiat Watershed Assessment) based on geomorphic type with a relatively high degree of structural diversity suitable for hiding cover by 2025.

Fish Passage Barriers

- Maintain and improve fish passage throughout the Assessment Unit by 2020.

Ecological

Reduce harassment to spawning and pre-spawning adult salmonids by 2010.

- Reduce poaching by 2010.

Predation

- Minimize piscivorous and avian predation on salmonids by 2015.

Food

- Improve nutrient base by 2010.

Hatchery

- Minimize hatchery contribution of pathogens by 2010.
- Minimize negative impacts of hatchery operations by 2010.

Middle Entiat River Assessment Unit

Water Quality

Sediment

- Decrease or maintain sediment loads to less than 12% fines (0.85mm) in spawning gravels throughout the Assessment Unit by 2020.
- Decrease substrate embeddedness conditions in the mainstem and tributaries by 2020.

Water Quantity

Flow

- Moderate severity of high flow events by enhancing floodplain conditions and in-channel complexity by 2025.

Riparian Floodplain

Riparian Condition:

- Improve riparian vegetation corridors and associated stream canopies where they have been degraded to a minimum of 75% of the estimated historic condition, where feasible by 2025
- Increase/maintain the number of large trees (site potential tree height) and complex riparian communities that will eventually increase the natural recruitment of LWD by 2025.
- Reduce impacts from development and livestock management within the riparian area by 2015.
- Reduce road density in riparian areas by 2025.

Floodplain Condition - Connectivity:

- Minimize affects of development on channel migration zones within the riparian and floodplain, and increase stream sinuosity in tributary streams through conservation or active restoration when feasible, by 2025.
- Increase, or reconnect floodplain (off-channel) habitats, where feasible, by 2025.

- Maintain and enhance wetland complexes, enhance ground water recharge by 2025.
- Remove bank armoring/dikes where applicable by 2025.
- Protect/enhance geo-fluvial processes and floodplain function from the moraine to the falls by 2025.

Road Density / Location

- Reduce road density to less than 1 miles/mi2 by 2030.
- Where feasible, relocate roads from the valley bottoms by 2030.

In-Channel

In Channel

- Maintain and enhance in-stream structural diversity and complexity to provide refuge to juveniles during high flow events by 2010.
- Protect and increase in-stream structures (complex log structures) by 2020.
- Increase stream bank stability using active and passive restoration techniques by 2015.
- Maintain and enhance habitat diversity by increasing off-channel habitat, backwaters with cover and low energy refugia by 2025.

LWD:

- Increase LWD to 20 pieces per mile (12”diameter > 35 ft length), restore large wood complexes and provide adequate sources for future woody debris recruitment in the riparian areas by 2025.

Pool Frequency and Quality:

- Increase quality pool (20 m2 by 1m deep) to an average of 9 pools per mile (Entiat Watershed Assessment) based on geomorphic type with a relatively high degree of structural diversity suitable for hiding cover by 2025.

Fish Passage Barriers

- Allow unimpeded access of fish passage throughout the tributaries by 2010.

Ecological

- Reduce or eliminate harassment to spawning and pre-spawning adult salmonids by 2010.
- Reduce or eliminate poaching by 2010.
- Eliminate or reduce impacts of eastern brook trout and hatchery rainbow trout by 2025.
- Maintain bull trout fishing closure and continue tracking bull trout populations.

Predation

- Minimize piscivorous and avian predation on salmonids by 2015.

Food

- Improve nutrient base by 2010.

Hatchery

- Minimize negative impacts of hatchery operations by 2010.
- Evaluate feasibility of coho reintroduction and begin implementation as appropriate.

Upper Entiat River Assessment Unit

Water Quality

Temperature:

- Maintain water temperatures

Sediment: Maintain sediment loads to 12% fines (0.85mm) in spawning gravels.

- Maintain unembedded conditions.

Water Quantity

Flow:

- Maintain the natural hydrograph.

Riparian Floodplain

Riparian Condition:

- Maintain riparian vegetation corridors and associated stream canopies and provide a minimum of 75% of the estimated historic condition, where feasible by 2025
- Maintain the number of large trees and complex riparian communities for natural recruitment of LWD.

In-Channel

In-Channel:

- Maintain in-stream structural diversity and complexity to provide refuge to juveniles during high flow events.

LWD:

- Maintain trend in LWD recruitment

Pool Frequency and Quality:

- Maintain quality pools (20 m2 by 1m deep) based on geomorphic type with a relatively high degree of structural diversity suitable for hiding cover.

Fish Passage Barriers

- Maintain unimpeded access of fish passage throughout the Assessment Unit.

Ecological

- Reduce or eliminate harassment to spawning and pre-spawning adult salmonids by 2010.
- Reduce or eliminate poaching by 2010.
- Eliminate or reduce impacts of eastern brook trout and hatchery rainbow trout by 2025.

Mad River Assessment Unit

Water Quality

Temperature:

- Maintain water temperatures

Sediment:

- Maintain or decrease sediment loads to, 12% fines (0.85mm) in spawning gravels.
- Maintain and/or improve road conditions to minimize or eliminate sediment delivery into the stream channel by 2020.
- Improve sediment (embeddedness) conditions in Tillicum Creek by 2020
- Maintain unembedded conditions in the mainstem.

Water Quantity

- Maintain the natural hydrograph.
- Decrease severity of high flow events by restoring geo-fluvial processes by 2025.
- Relocate roads from the valley bottoms where feasible by 2030.

Riparian Floodplain

Riparian Condition:

- Reestablish riparian vegetation corridors and associated stream canopies where they have been degraded to a minimum of 75% of the estimated historic condition, where feasible by 2025
- Reduce road density in tributaries by 2025
- Protect riparian vegetation and maintain trend in natural recruitment of LWD.

Floodplain Condition:

- Maintain and improve in lower Mad River and other localized areas by 2025.

- Protect fluvial processes and floodplain function by 2025.

Road Density / Location:

- Reduce road density to less than 1 miles/mi2 by 2030.
- Where feasible, relocate roads from the valley bottoms by 2030.

In-Channel

In-Channel:

- Maintain and enhance in-stream structural diversity and complexity in the lower Mad River by 2015.

LWD:

- Maintain trend in natural recruitment of LWD.

Pool Frequency and Quality:

- Maintain quality pools (20 m2 by 1m deep) at an average of 9 pools per mile (Entiat Watershed Assessment) based on geomorphic type with a relatively high degree of structural diversity suitable for hiding cover.

Fish Passage Barriers

- Maintain unimpeded access of fish passage throughout the Assessment Unit.

Ecological

- Reduce harassment to spawning and pre-spawning adult salmonids by 2010.
- Reduce poaching by 2010.

Predation

- Minimize piscivorous and avian predation on salmonids by 2015.

Food

- Improve nutrient base by 2010.

Hatchery

- Minimize negative impacts of hatchery operations by 2010.

7.6.4 Management Strategies

Strategies are set so factions to accomplish the biological goals. Strategies will serve as guidance on proposed projects in the future to achieve the objectives.

General Watershed

- Reduce or eliminate brook trout by removing harvest limit and encouraging public participation through education.

- Hold annual fishing derbies for brook trout.
- Electro-fish brook trout off spawning grounds.

Lower, Middle Entiat River, and Mad River Assessment Units

Water Quality

Temperature:

- Evaluate the effect of temperatures using FLIR, or other technology, on current and potential life histories and habitat use.
- Study egg/juvenile overwinter survival
- Evaluate effects of low temperatures on the productivity of native species.
- Initiate analysis and monitoring of anchor / frazil ice and its effects on macro-invertebrates and fish (spawning and over-winter rearing habitat) and the relationship, if any, to riparian vegetation and floodplain conditions.
- Evaluate effects of side channels and off channel habitat on instream summer temperatures
- Moderate summer water temperatures by improving riparian conditions.
- Use FLIR or other technology to identify winter and summer refugia.

Sediment

- Maintain and improve road conditions to minimize or eliminate sediment delivery into the stream channel.
- Continue monitoring sediment yield on an annual basis.
- Reduce localized streambank erosion.

Contaminants

- Continue upgrades of failing/old septic systems
- Prevent direct access of livestock to streams via fencing
- Reevaluate bioaccumulation of toxins and heavy metals in native fishes within the Entiat subbasin.
- Reduce pesticide and herbicide use near riparian zones by public education and incentive.

Water Quantity

- Investigate and implement programs designed to increase efficiency of water withdrawal.

- Decrease summer surface withdrawals by converting water withdrawals to ground water wells.
- Continue to improve irrigation efficiencies within the lower Entiat.
- Decrease summer surface withdrawals by converting water withdrawals to ground water wells.
- Explore the potential for water storage for late season use.

Riparian Floodplain

Riparian Condition:

- Increase nutrient recruitment of detritus from riparian vegetation by increasing riparian growth and floodplain connectivity.
- Protect and enhance riparian vegetation along unstable stream banks.
- Protect / enhance fluvial processes and floodplain function.
- Preserve high quality riparian patches as refuge habitats.
- Define hyporheic zone with natural flow regimes
- Evaluate fish use of off channel habitats.
- Prevent direct access of livestock to streams via fencing

Floodplain Condition – Connectivity:

- Reconnect and increase side-channel habitat to the main stream channel.
- Where appropriate, establish areas where natural channel migration can occur In-Channel

In-Channel:

- Where appropriate, provide in-stream structures (large wood, rock or other natural materials) that will enhance salmonid habitat diversity, habitat quality and quantity and channel -integrity.

LWD:

- Restore large wood complexes, passively and actively.

Pool frequency and Quality:

- Passively and actively restore in-stream structure that will increase juvenile rearing habitat and geo-fluvial processes that will encourage pool formation.

Ecologic

- Initiate/improve public outreach programs to eliminate harassment and poaching.

- Evaluate the feasibility and implement where appropriate, the introduction of beneficial species to the watershed or subbasin (noxious weed control)
- Evaluate carrying capacity for space and food resources to determine if elevated competition is occurring.

Predation:

- Evaluate piscivorous and avian predation on salmonids.

Pathogens:

- Study presence of pathogens in juveniles and adults.

Hatchery:

- Evaluate the use of artificial production (supplementation) to enhance recovery of target species.
- Continue to evaluate the composition of the Entiat spring Chinook and steelhead.
- Continue to evaluate ecologic interactions between coho and Chinook interactions.
- Continue evaluating spawning interaction between hatchery and wild fish.

Food:

- Evaluate nutrient cycling and carcass increases.
- Monitor and evaluate the productivity of macroinvertebrate production.

Upper Entiat River Assessment Unit

General Watershed

- Manage for cutthroat trout above Entiat Falls and remove brook trout.
- Evaluate bull trout populations above the falls.

Water Quality

Temperature:

- Evaluate the effect of temperatures on current and potential life histories and habitat use.

Sediment:

- Continue monitoring sediment yield on an annual basis.

Water Quantity

- Evaluate the potential for water storage within the subbasin.

Riparian Floodplain

- Restore natural hyporheic zone with natural flow regimes

Ecologic

- Initiate/improve public outreach programs to eliminate harassment and poaching.
- Evaluate the feasibility and implement where appropriate, the introduction of beneficial species to the watershed or subbasin (noxious weed control).

Food:

- Monitor and evaluate the productivity of macroinvertebrate production

7.7 Research, Monitoring, and Evaluation

Research within this plan is based on the objectives and strategies outlined in previous sections. The following compiles most of the recommended elements within the Technical Guide for Subbasin Planners, and also incorporates the hypothesis statements for each assessment unit. Key findings, objectives, and strategies that relate only to the hypothesis statements are also listed to show how they interrelate.

Within the Research section, data gaps are identified within the element of "additional informational needs." The Monitoring and Evaluation section lists various tables from which potential project proponents can determine various indicators to measure and how they relate to strategies.

7.7.1 Working hypotheses

Water Quality

Decreasing elevated summer water temperatures to a maximum of 16 °C throughout the Entiat subbasin will increase survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the following life stages: spawning, incubation, emergence, and rearing.

Water Quantity

Maintaining the current flow regime throughout the Entiat Subbasin will support and maintain an increase in survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the following life stages: spawning, incubation, emergence, rearing, and pre-spawn holding.

Key findings supporting hypothesis

- Water temperatures are believed to be elevated from historic levels.
- Conditions are exacerbated during low flow years.
- Water temperature typically exceeds state water quality standards from July through September, although exceedences are usually of short duration and diurnal in nature.
- Mainstem and tributary flows are highly variable and very responsive to local weather.
- Peak flow timing is assumed to be at or near historic conditions, with current peak flows showing signs of recovery from past fires.

- Low flows are a natural occurrence within the subbasin.
- Irrigation water use during the low summer flow period, coupled with increased channel width-to-depth ratio in the lower Entiat River, may exacerbate poor conditions.

Biological objectives

1. Reduce impact of temperature on incubation, rearing, and migrating adults so it does not exceed the 7 day average maximum within any reach by 2020.
2. Reduce impact, and increase efficiency of water withdrawal during August and September by 2020.
3. Decrease severity of high flow events by increasing in-channel structural diversity and restoring geo-fluvial processes by 2025.
4. Relocate roads from the valley bottoms where feasible by 2030.
5. Moderate severity of high flow events by enhancing floodplain conditions and in-channel complexity by 2025.

Strategies

1. Moderate summer water temperatures by improving riparian conditions.

Increasing riparian growth will increase shade and associated water cooling. Priority is moderate-high.

2. Use FLIR or other technology to identify winter and summer refugia.

The use of the FLIR or other technology will aid in the measurement and location of those areas that may need to be conserved, or protected. It may also identify areas that are potentially problematic. Priority is high.

3. Decrease summer surface withdrawals by converting water withdrawals to ground water wells.

Moderate increases in ground water use may aid in the reduction of withdrawal of surface water, increasing instream flow. Priority is moderate to high.

Continue to improve irrigation efficiencies within the lower Entiat.

Increased efficiency will aid in the reduction of withdrawal, thus increasing instream flow. Priority is high.

4. The priorities of the strategies are based on the potential impacts and feasibility of implementing programs that would occur under these strategies.

Research

Additional informational needs (data gaps)

1. Effect of temperatures on current and potential life histories and habitat use.

The effect of extreme high and low temperatures on current and potential life histories and habitat use is not well known.

2. Effects of side channels and off channel habitat on instream summer temperatures.

Side channels may incorporate ground water that is currently not available that may cool temperatures.

3. Evaluate the potential for water storage within the subbasin.

Water is available for storage during certain periods, however potential sites for water storage (off-channel, aquifer, other) have not been identified or evaluated.

4. Monitor actual water use.

Actual water use has not been documented.

Approach (general experimental design)

- Installation of temperature recorders at strategic locations.
- Use of FLIR technology for all seasons.
- Evaluate potential ground water infusion sites.
- Implement a feasibility study to determine likely water storage sites

Statistical analyses

- Both descriptive statistics and graphing methods will be used to analyze data.

Spatial scale

- Temperature recorders will be installed in areas that do not have current temperature information throughout the lower and middle Assessment Units.
- Potential off-channel habitat sites should be identified throughout the lower and middle Assessment Units.
- Potential water storage would need to be upstream of current withdrawals, if it was the most cost effective strategy.

Temporal scale

- Temperature recordings should be on-going indefinitely.
- Potential off-channel habitat sites should be identified within two years
- Potential water storage sites should be located within two years.

Budget

- To be determined, although it is assumed that a consortium of agencies would take the lead in this effort.

Deliverable

- Draft annual report due December 15 of the year the research takes place
- Final annual progress reports due March 1 of the year following the research
- Final report due by July 1 after the final year of research

Data

- Data will be collected and entered in either spreadsheet or data base format, as agreed to by the lead agencies.
- Data will be stored by the lead agency, unless other collaboratively agreed upon arrangements are made.
- All data will be available upon request to other agencies or the public

7.7.2 Working hypotheses

Water Quality

Reducing point source and/or non-point source pollution in the Lower and Middle reaches will increase survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the following life stages: spawning, incubation, emergence, rearing, and pre-spawn holding.

Riparian Floodplain

Increasing riparian shade will decrease instream temperatures thus increasing survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the Lower and Middle Entiat for the following life stages: spawning, incubation, emergence, rearing, and pre-spawn holding.

Improving or restoring riparian floodplain will increase floodplain function and overall health within the Lower and Middle Entiat, and the Mad River.

Contaminants

Maintaining or lowering contaminant levels within the Lower and Middle Entiat to at or below Clean Water Act standards will prevent 303d listings and increase the health and survival of all focal species using the areas.

In-channel Habitat

Increased channel complexity and diversity will increase survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the Lower and Middle Entiat for the following life stages: spawning, incubation, emergence, rearing, and pre-spawn holding.

Sediment

Maintaining or reducing sediment loads will increase survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the Lower and Middle Entiat for the following life stages: spawning, incubation, emergence, rearing, and pre-spawn holding.

Nutrients

Increasing nutrient loads will increase survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the Lower and Middle Entiat for the following life stages: spawning, incubation, emergence, rearing, and pre-spawn holding

Harassment

Reduction of harassment will increase survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the Lower and Middle Entiat for the following life stages: spawning and pre-spawn holding.

Barriers

Providing passage to native salmonids will increase survival of spring Chinook, summer/fall Chinook, steelhead, and bull trout in the Lower and Middle Entiat for the following life stages: spawning, incubation, emergence, rearing, and pre-spawn holding.

Key findings supporting hypothesis

- Water temperatures are believed to be elevated from historic levels.
- Conditions are exacerbated during low flow years.
- Water temperature typically exceeds state water quality standards from July through September, although exceedences are usually of short duration and diurnal in nature.
- The use of herbicides and pesticides in lower Entiat may affect focal species health.
- The Lower Entiat lies within the depositional zone of the subbasin.
- Road densities, unstable banks, and natural/human caused disturbance events all contribute to fine sediment conditions.
- The 11-year trend of sediment deposition appears to be increasing in the lower AU and decreasing in the middle and Mad AUs.
- Irrigation water use during the low summer flow period, coupled with increased channel width-to-depth ratio in the lower Entiat River, may exacerbate naturally occurring poor conditions.
- Riparian conditions near confluence with the Columbia River show substantial vigor and contribute positively to stream channel diversity and properly functioning conditions.
- Channel straightening, clearing and diking/bank armoring have substantially changed riparian and floodplain conditions.
- Riparian cover is reduced (in various degrees) and LWD recruitment ranges from poor to fair. Filling and diking has eliminated floodplain connection in areas.

- In some reaches, loss of vigorous shrubs in the riparian zone has reduced instream organic input and shade, and contributed to unstable stream banks and associated erosion.
- Channel morphology has been significantly simplified as a result of mid-1900's channel straightening / widening, diking, and bank armoring.
- The lower Entiat has been changed in many reaches to a Rosgen F type channel, resulting in a high width-to-depth ratio, channelization, stream down-cutting, and a substantial lack of habitat diversity.
- Pool habitat has been reduced significantly from historic conditions.
- Quality and quantity of rearing and holding habitat, off-channel winter rearing habitat, and spawning habitat are considered to be fair to poor throughout most of the Lower Entiat River.
- There are no physical structures in the lower mainstem Entiat River.
- Food resources (macro invertebrate production) for juvenile salmonids have likely decreased since the historic reference condition as a result of increased water temperatures and decreased organic inputs and nutrient loads.
- Reduced salmonid carcasses, reduced riparian / leaf litter and reduced floodplain function may have contributed to a lowering of the nutrient content and benthic macro invertebrate production within the lower Entiat.
- Harassment of adult salmonids is largely a function of lack of hiding cover coupled with recreation use of the river.
- At this time there is no formal public outreach to educate people of the sensitivity of these fish to disturbance, especially during adult holding and spawning times.
- Riparian clearing and roading has likely resulted in bank erosion and increased sediment delivery in some areas.
- Riparian clearing and roading has resulted in a loss of side channel habitats, backwater pools and stream / riparian interface.
- General channel features, such as sinuosity, width/depth ratios exhibit near normal features. Localized bank erosion, and loss of habitat diversity and channel complexity is apparent due to stream channel clearing and development.
- In low-gradient areas, loss of side channel habitat has resulted in a loss of off-channel refugia during high flows.
- Passage in several tributary streams is hindered or blocked, primarily for juvenile life stages.
- The amount of habitat upstream of tributary culvert barriers is limited.

Biological objectives

1. Reduce toxic pesticide and herbicides in the riparian areas and water system so that stress, cumulative effects and/or direct mortality on all fish species for all life stages have been eliminated by 2025.

2. Reduce or eliminate waste materials from surface and ground waters from failing septic systems and livestock by 2015.

3. Reduce or maintain effluent for Entiat National Fish Hatchery at or below CWA standards by 2010.

4. Decrease sediment loads to 12% fines (0.85mm) in spawning gravels by 2020.

5. Improve substrate embeddedness conditions in tributaries by 2020.

6. Reestablish riparian vegetation corridors and associated stream canopies where they have been denuded to a minimum of 75% of the estimated historic condition, where feasible by 2025

7. Increase the number of large trees (site potential tree height) and complex riparian communities that will eventually increase the natural recruitment of LWD by 2025.

8. Restore (lower AU), maintain and enhance (middle AU and Mad AUs) in-stream structural diversity and complexity to provide refuge to juveniles during high flow events by 2020.

9. Increase stream bank stability using active and passive restoration techniques, where feasible, by 2015.

10. Protect and increase in-stream structures (complex log structures) by 2020.

11. Increase stream bank stability using active and passive restoration techniques by 2015.

12. Maintain and enhance habitat diversity by increasing off-channel habitat, backwaters with cover and low energy refugia by 2025.

13. Allow unimpeded access of fish to spawning and rearing areas by 2020.

14. Reduce harassment to spawning and pre-spawning adult salmonids by 2010.

15. Reduce poaching by 2010.

16. Improve nutrient base by 2010.

Strategies

1. Maintain and improve road conditions to minimize or eliminate sediment delivery into the stream channel.

Improving road conditions will reduce bank failure and subsequent sediment delivery. Priority mod-high.

2. Continue upgrades of failing/old septic systems.

This strategy will decrease non-point source contaminants. Priority mod-high.

3. Prevent direct access of livestock to streams via fencing

Removing livestock from riparian areas will increase riparian growth and reduce potential source of contaminants. Priority moderate.

4. Initiate/improve public outreach programs to eliminate harassment and poaching.

Improving public knowledge should decrease the likelihood of local people harming focal species. Priority moderate.

5. Evaluate effects of low temperatures on the productivity of native species.

Understanding egg and juvenile fish survival during winter will aid managers in setting realistic recovery levels. Priority moderate.

6. Initiate analysis and monitoring of anchor / frazil ice and its effects on macro-invertebrates and fish (spawning and over-winter rearing habitat) and the relationship, if any, to riparian vegetation and floodplain conditions.

Ice complexes may scour aquatic and terrestrial habitat when in movement. Priority mod-low.

7. Evaluate effects of side channels and off channel habitat on instream summer temperatures

Infusion of ground water may decrease high summer temperatures. Priority mod-high.

8. Evaluate nutrient cycling and carcass increases.

Understanding nutrient relationships will aid in our understanding of focal species productivity. Priority moderate.

9. Monitor and evaluate the productivity of macroinvertebrate production

    Macroinvertebrates are important food items for juvenile focal species. Priority moderate.

10. Evaluate the feasibility and implement where appropriate the introduction of beneficial species to the watershed or subbasin. (noxious weed control)

Removing noxious weeds will aid in the recovery of riparian areas. Priority mod-high.

11. Evaluate carrying capacity for space and food resources to determine if elevated competition is occurring.

Understanding carrying capacity will aid managers in setting realistic recovery levels. Priority moderate.

12. Restore large wood complexes

Restoration of large wood complexes will increase juvenile rearing and adult holding habitat, help create additional pools and general habitat diversity. Priority high.

13. Reconnect and increase side-channel habitat to the main stream channel

Reconnecting side channels will increase habitat diversity and increase juvenile productivity. Priority high.

14. Where appropriate, establish areas where natural channel migration can occur

Reconnecting side channels will increase off channel rearing and habitat diversity and increase juvenile productivity. Priority high.

15. Where appropriate, provide in-stream structures (large wood, rock or other natural materials) that will enhance salmonid habitat diversity, habitat quality and quantity and channel -integrity.
16. Restoration of large wood complexes will increase juvenile rearing and adult holding habitat, help create additional pools and general habitat diversity. Priority high.

The priorities of the strategies are based on the potential impacts and feasibility of implementing programs that would occur under these strategies.

Research

Additional informational needs (data gaps):

- Reevaluate bioaccumulation of toxins and heavy metals in native fishes within the Entiat subbasin. The level and extent of DDT/PCB contamination is unknown. Bioaccumulation of toxins and heavy metals in native fishes should be reevaluated.
- Define hyporheic zone with natural flow regimes. The extent of the hyporheic zone has not been delineated under natural flow regime.
- Fish use of off channel habitats. Fish use of off channel habitats has not been determined.
- Assess fish passage. The effects of potential thermal barriers on late-run Chinook are unknown. The extent to which some irrigation pumps / diversions and tributary culverts may not meet standards for fish passage and/or screening has not been assessed.
- Evaluate nutrient cycling, carcass increases, and productivity of macroinvertebrate production. Nutrient cycling, the effects of carcass supplementation, and the health/productivity of macroinvertebrate populations have not been evaluated.
- Continue monitoring sediment yield on an annual basis. Monitoring of fine sediment yield on an annual basis should continue.
- Document disparity between actual water use and the amount of water represented by rights and claims. This will increase water use efficiency.
- Determine areas of surface water-groundwater interchange and subsurface water movement. This will increase our ability to moderate temperatures.

- Determine the effects of cold water temperature and anchor ice on egg and fry survival. Understanding these processes will increase our ability to set realistic recovery goals.
- Assess extent to which some irrigation pumps / diversions and tributary culverts meet standards for fish passage and/or screening Rectifying these problems will increase juvenile survival and increase habitat availability.
- Determine areas for in-stream structure placement. Strategic sites need to be identified before structures can be placed in the stream channel.

Approach (general experimental design)

- Sample (bioassays) and monitor toxins in fish tissue.
- Monitor temperature

1. for ground water infusion (FLIR)
2. barrier for adults (temperature gauges)
3. over-winter survival of eggs and juveniles (temperature gauges, FLIR)

- Passive restoration of riparian areas (fencing only)
- Active restoration of riparian areas (fencing, plantings, etc.)
- Placement of in-stream structures, where appropriate (active).
- Encourage in-stream structure (passive).
- Remove or set back dikes where appropriate
- Water quality sampling

1. nutrient load (could be effectiveness monitoring)
2. toxins

- Snorkeling surveys to:

1. observe focal species within off channel habitats;
2. determine life history needs of focal species.
3. effectiveness monitoring of in-stream structures

- Electrofish:

To determine numbers and diversity of fish within a sample reach

- Monitor migration of adult summer/fall chinook in relationship to temperature.
- Sample nutrient load within sample reaches.
- Sample for sediment deposition on regular schedule.

Statistical analyses

- Both statistical and graphical methods will be used to analyze data. Statistical methods will include descriptive statistics, trend analysis (changes in trend before and after implementation of management actions), multiphase regression, and t-tests with before-after and before-after-control-impact designs. Depending on the characteristics of the data, nonparametric procedures like the randomization test, Wilcoxon rank sum test, or the Mann-Whitney test may be used.

Spatial scale

- Various sample reaches within all assessment units.

Temporal scale

- Some monitoring should occur on an annual basis.
- Most other work could be completed within five years.

Budget

- To be determined, although it is assumed that a consortium of agencies would take the lead in this effort.

Deliverable

- Draft annual report due December 15 of the year the research takes place
- Final annual progress reports due March 1 of the year following the research
- Final report due by July 1 after the final year of research

Data

- Data will be collected and entered in either spreadsheet or data base format, as agreed to by the lead agencies.
- Data will be stored by the lead agency, unless other collaboratively agreed upon arrangements are made.
- All data will be available upon request to other agencies or the public

Working hypotheses

Exotic Species

Reduction in exotic species will increase survival of steelhead, bull trout and westslope cutthroat trout in the Middle and Upper Entiat for the following life stages: spawning, incubation, emergence, rearing, and pre-spawn holding.

General Habitat

Maintaining current habitat conditions will increase the probability of success for programs initiated in other parts of the subbasin to increase productivity of focal species.

Key findings supporting hypothesis

- Brook trout have been introduced and remain in this assessment unit.
- Exogenous rainbow trout are also established.
- Water quality is at pristine condition.
- Flows are at or near the historic reference condition.
- Riparian and floodplain attributes are stable and considered to be in good to excellent condition and are at or near the historic reference condition.
- Some localized compaction and disturbance of riparian vegetation is noted due primarily to trails / recreation, although these are minor at the watershed scale.
- In-channel attributes are considered to be in good to excellent condition and near historic reference condition.
- There are no man-made barriers to fish passage in these Assessment Units.

Biological objectives

1. Eliminate or reduce impacts of eastern brook trout and hatchery rainbow trout by 2025.
2. Maintain water temperatures
3. Maintain sediment loads to 12% fines (0.85mm) in spawning gravels.
4. Maintain unembedded conditions.
5. Maintain the natural hydrograph.
6. Maintain riparian vegetation corridors and associated stream canopies and provide a minimum of 75% of the estimated historic condition, where feasible by 2025
7. Maintain the number of large trees and complex riparian communities for natural recruitment of LWD.
8. Maintain in-stream structural diversity and complexity to provide refuge to juveniles during high flow events.
9. Maintain trend in LWD recruitment
10. Maintain quality pools (20 m^2 by 1m deep) based on geomorphic type with a relatively high degree of structural diversity suitable for hiding cover.
11. Maintain unimpeded access of fish passage throughout the Assessment Units.
12. Reduce or eliminate harassment to spawning and pre-spawning adult salmonids by 2010.
13. Reduce or eliminate poaching by 2010.

Strategies

- Reduce or eliminate brook trout by removing harvest limit and encouraging public participation through education.

Educating the public to the negative effects of brook trout on focal species will increase the probability of public support and help for removal. Priority high.

- Hold annual fishing derbies for brook trout.

Fishing derbies may assist fishery managers in the effort to reduce the impact of brook trout. Priority mod.-low.

- Electro-fish brook trout off spawning grounds.

Hook and line fisheries will most likely need to be supplemented to effectively reduce/remove brook trout populations within the basin. Priority mod.-high.

- Manage for cutthroat trout above Entiat Falls and remove brook trout.

Reduction of brook trout will reduce potential negative interactions with westslope cutthroat trout.

- Evaluate bull trout populations above the falls.

Distribution throughout the basin is poorly understood.

- Evaluate the effect of temperatures on current and potential life histories and habitat use.

Understanding life history requirements will aid in recovery of focal species.

- Evaluate the potential for water storage within the subbasin.

A water storage facility in the upper basin would moderate water withdrawal in the lower basin and potentially moderate naturally limiting water temperatures.

- Initiate/improve public outreach programs to eliminate harassment and poaching.

Without public buy-in for reduction of poaching and harassment, efforts will most likely be futile.

- Monitor and evaluate the productivity of macroinvertebrate production.

Macroinvertebrate populations are key for juvenile food.

The priorities of the strategies are based on the potential impacts and feasibility of implementing programs that would occur under these strategies.

Research

Additional informational needs (data gaps)

- Reevaluate bioaccumulation of toxins and heavy metals in native fishes within the Entiat subbasin.

- Evaluate the effect of temperatures on current and potential life histories and habitat use.
- Feasibility study for water storage within the subbasin.
- Surveys to determine presence of bull trout populations above Entiat Falls.
- Survey to determine bull trout abundance and distribution throughout the Entiat Watershed.
- Evaluate effects of hatchery stocking programs on current native populations of rainbow and cutthroat trout.
- Evaluate effects of brook trout on native species and extent of genetic alteration within the native fish populations
- The variability of stream channel sinuosity, width/depth ratio, and riparian coverage from fixed stations is not well understood in middle AU.
- The extent that the public harasses fish is not well understood, especially at high use areas, such as campgrounds.

Approach (general experimental design)

- Sample (bioassays) and monitor toxins in fish tissue.
- Monitor temperature

for ground water infusion (FLIR)

over-winter survival of eggs and juveniles (temperature gauges, FLIR)

- Water quality sampling

nutrient load (could be effectiveness monitoring)

toxins

- Snorkeling surveys to:
  1. determine life history needs of focal species.
  2. determine negative interactions between focal and exogenous species
- Electrofish:

to determine numbers and diversity of fish within a sample reach

Sample nutrient load within sample reaches.

Statistical analyses

- Both statistical and graphical methods will be used to analyze data. Statistical methods will include descriptive statistics, trend analysis (changes in trend before and after implementation of management actions), multiphase regression, and t-tests with before-after and before-after-control-impact designs. Depending on the characteristics of the data, nonparametric procedures like the randomization test, Wilcoxon rank sum test, or the Mann-Whitney test may be used.

Spatial scale

- Various sample reaches within both assessment units.

Temporal scale

- Some monitoring should occur on an annual basis.
- Most other work will be completed within five years.

Budget

- To be determined, although it is assumed that a consortium of agencies would take the lead in this effort.

Deliverable

- Draft annual report due December 15 of the year the research takes place
- Final annual progress reports due March 1 of the year following the research
- Final report due by July 1 after the final year of research

Data

- Data will be collected and entered in either spreadsheet or data base format, as agreed to by the lead agencies.
- Data will be stored by the lead agency, unless other collaboratively agreed upon arrangements are made.
- All data will be available upon request to other agencies or the public

Monitoring and Evaluation

The monitoring and evaluation (M&E) section of this plan incorporates the general approach outlined within the Technical Guide for Subbasin Planners. Within this plan, a potential framework and steps are identified to help design the M&E plan, however this information is still considered very preliminary. This potential framework has been broken down into tables to incorporate the information easily for potential project planners. One additional step is included; a table showing “commonality” between the monitoring needs. This was developed to show that many of the methods employed or indicators measured, will be able to be used over more than one strategy.

This framework is consistent with the Moniotoring Stategy for the Upper Columbia Basin (February 2004) incorporated in this document as Appendix B.

Table 26. Monitoring and evaluation indicators for all assessment units.

General characteristics	Specific indicators	Main Strategies									
Biological		***Reduce or eliminate brook trout***	***Moderate summer and winter temperature***	***Identify summer and winter refugia***	***Reduce sediment***	***Determine contaminant levels***	***Reduce impacts of water withdrawal***	***Increase riparian area and function***	***Increase off - channel habitat***	***Increase in-channel diversity and structure***	***Reduce poaching and harassment***
Adults	Escapement/ Number	X		X							X
	Age structure										
	Size										
	Sex ratio										
	Run timing	X	X								X
	Origin (hatchery/ wild)										
	Fecundity										
Redds	Number	X					X				
	Distribution	X	X				X				
	Egg survival				X						
	Timing		X				X				
Parr/	Abundance	X	X	X			X	X	X	X	

General characteristics	Specific indicators	Main Strategies									
Biological		***Reduce or eliminate brook trout***	***Moderate summer and winter temperature***	***Identify summer and winter refugia***	***Reduce sediment***	***Determine contaminant levels***	***Reduce impacts of water withdrawal***	***Increase riparian area and function***	***Increase off-channel habitat***	***Increase in-channel diversity and structure***	***Reduce poaching and harassment***
Juveniles	Distribution/ Habitat use	X	X	X			X	X	X	X	
	Size	X	X	X			X	X	X	X	
Interactions	Predator/ prey	X						X	X	X	
	Displacement	X	X	X				X		X	
	Interbreed	X									
Habitat											
Water Quality	MWMT and MDMT		X	X			X	X		X	
	Turbidity				X						
	Conductivity					X					
	pH					X					
	Dissolved oxygen		X	X		X	X				
	Nitrogen					X					
	Phosphorus					X					

General characteristics	Specific indicators	Main Strategies									
Biological		***Reduce or eliminate brook trout***	***Moderate summer and winter temperature***	***Identify summer and winter refugia***	***Reduce sediment***	***Determine contaminant levels***	***Reduce impacts of water withdrawal***	***Increase riparian area and function***	***Increase off - channel habitat***	***Increase in-channel diversity and structure***	***Reduce poaching and harassment***
Habitat Access	Road crossings			X				X	X		
	Diversion dams			X			X		X		
	Timing		X	X					X		
	Barriers			X			X		X		
Habitat Quality	Dominant substrate			X	X	X		X		X	
	Embeddedness			X	X			X		X	
	Depth fines				X			X		X	
	LWD (pieces/km)			X				X	X	X	
	Pools (pools/km)			X			X			X	
	Residual pool depth			X			X			X	
	Fish cover			X			X	X	X	X	
	Side channels and backwaters			X	X		X	X	X	X	

General characteristics	Specific indicators	Main Strategies									
Biological		***Reduce or eliminate brook trout***	***Moderate summer and winter temperature***	***Identify summer and winter refugia***	***Reduce sediment***	***Determine contaminant levels***	***Reduce impacts of water withdrawal***	***Increase riparian area and function***	***Increase off - channel habitat***	***Increase in-channel diversity and structure***	***Reduce poaching and harassment***
Channel condition	Stream gradient			X	X	X			X	X	
	Width/depth ratio		X	X	X		X	X	X	X	
	Wetted width			X	X		X	X	X	X	
	Bankfull width			X	X		X	X	X	X	
	Bank stability				X			X	X	X	
Riparian Condition	Riparian structure		X	X	X			X	X	X	
	Riparian disturbance				X			X	X	X	X
	Canopy cover		X		X			X			X
Flows and Hydrology	Streamflow		X	X	X		X	X	X	X	
Watershed Condition	Watershed road density				X			X	X	X	
	Riparian-road index				X			X	X	X	

General characteristics	Specific indicators	Main Strategies									
Biological		***Reduce or eliminate brook trout***	***Moderate summer and winter temperature***	***Identify summer and winter refugia***	***Reduce sediment***	***Determine contaminant levels***	***Reduce impacts of water withdrawal***	***Increase riparian area and function***	***Increase off - channel habitat***	***Increase in-channel diversity and structure***	***Reduce poaching and harassment***
	Land ownership				X	X	X	X	X	X	X
	Land use			X	X	X	X	X	X	X	X

Table 27. Commonality between monitoring needs for the Enitat subbasin

Category	**Metric or method**	***Reduce or eliminate brook trout***	***Moderate summer and winter tempera-ture***	***Identify summer and winter refugia***	***Reduce sed-iment***	***Determine contamin-ant levels***	***Reduce impacts of water withdrawal***	***Increase riparian area and function***	***Increase off - channel habitat***	***Increase in-channel diversity and structure***	***Reduce poaching and harass-ment***
Adults	Spawning ground surveys	X	X				X	X			X
	Estimate of abundance	X					X	X			X
	Interactions with native species	X	X	X			X			X	
	Interaction with exogenous species	X	X	X			X			X	
	Bioassay					X					
	Movement	X	X	X			X	X		X	
	Run timing		X	X			X				
Egg Juveniles	Emergence timing	X	X	X	X						
	Egg survival		X		X						
	Distribution	X	X	X			X	X	X	X	
	Interactions with native species	X	X	X			X		X	X	

Category	Metric or method	*Reduce or eliminate brook trout*	*Moderate summer and winter tempera-ture*	*Identify summer and winter refugia*	*Reduce sed-iment*	*Determine contamin-ant levels*	*Reduce impacts of water withdrawal*	*Increase riparian area and function*	*Increase off - channel habitat*	*Increase in-channel diversity and structure*	*Reduce poaching and harass-ment*
	Interaction with exogenous species	X	X	X			X		X	X	
	Bioassays					X					
	Abundance	X	X	X			X	X	X	X	
Methods-fish	Snorkel	X	X	X			X	X	X	X	
	Electro-fish	X	X				X	X	X	X	
	Active tag & track	X	X	X			X		X	X	
	Hook & line	X									
	Creel survey	X									
Methods-habitat	Passive restoration		X		X			X	X	X	X
	Active restoration		X		X			X	X	X	X
	Instream structures				X				X	X	X
	FLIR		X	X							
	Temperature recorders		X	X				X			
	McNeil core sampling				X						

Category	**Metric or method**	***Reduce or eliminate brook trout***	***Moderate summer and winter tempera-ture***	***Identify summer and winter refugia***	***Reduce sed-iment***	***Determine contamin-ant levels***	***Reduce impacts of water withdrawal***	***Increase riparian area and function***	***Increase off - channel habitat***	***Increase in-channel diversity and structure***	***Reduce poaching and harass-ment***
	Increase ground water use						X				
	Storage reservoir						X				
	Remove or set back dikes		X					X	X		

Table 28. Planning, design, and standards for the Entiat subbasin

Category	Metric/ responsibility	Reduce or eliminate brook trout	Moderate summer and winter temperature	Identify summer and winter refugia	Reduce sediment	Determine contaminant levels	Reduce impacts of water withdrawal	Increase riparian area and function	Increase off -channel habitat	Increase in-channel diversity and structure	Reduce poaching and harassment
Evaluation planning	Evaluation responsibility	WDFW, USFS, USFWS, YN	EPU, USFS, DOE, YN	EPU, USFWS, USFS, WDFW, YN	EPU, USFS, DOE, YN	DOE, WDFW, USFWS, YN	EPU, DOE, USFWS, USFS, YN	EPU, DOE, USFWS, USFS, YN	EPU, DOE, USFWS, USFS, YN	EPU, DOE, USFWS, USFS, YN	WDFW, YN
	Decision responsibility	USFWS, WDFW, YN	DOE, YN	USFWS, WDFW, YN	USFS, YN	DOE, YN	DOE, YN	EPU, YN	WDFW, YN	WDFW, YN	WDFW, YN
	Public feedback	2x/yr	4x /yr	2 x/yr	4 x /yr	2 x/yr	4 x /yr	4 x /yr	4 x /yr	4 x /yr	4 x /yr
	Potential cost share (mostly personnel)	USFWS, USFS, WDFW, YN	USFS, DOE, USFWS, YN	USFWS, USFS, WDFW, YN	USFS, DOE, USFWS, YN	DOE, WDFW, USFWS, YN	USFS, DOE, USFWS, YN	USFS, DOE, USFW, YNS	USFS, DOE, USFWS, YN	USFS, DOE, USFWS, YN	WDFW, EPU, YN
Sampling design*	Monitoring	S/T & E	S/T	S/T	S/T	S/T	S/T	S/T & E	S/T & E	S/T	S/T
	Frequency	3 x/yr	Continuously	4 x in summer and then again in winter	Quarterly, plus after major events	2 x/yr	Low flow during late summer	3 x/yr	3 x/yr	3 x/yr	Contin-uously
	Methods	Snorkel, electro-shocking	FLIR (winter), and gauges	Snorkel	McNeil core samples	Bioassay	Increased use of ground water, storage reservoir	Active and passive restoration	Remove or set back dikes, use of irrigation cannels for rearing,	Instream structure, more LWD recruitment	Public education, outreach, public "enforce-ment"
Statistical	Significance level	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Category	Metric/ responsibility	Reduce or eliminate brook trout	Moderate summer and winter temperature	Identify summer and winter refugia	Reduce sediment	Determine contaminant levels	Reduce impacts of water withdrawal	Increase riparian area and function	Increase off-channel habitat	Increase in-channel diversity and structure	Reduce poaching and harassment
ns	Hypothesis	Middle and Upper AUs	Lower AU	Lower Entiat and Mad AUs	Lower AU	Lower, Middle, Mad AUs	Lower AU	Lower AU	Lower AU	Lower and middle Aus	All AUs
Performance standards	Reference	Presumed effects	Current conditions	Current conditions	Current rats of deposition	Current levels	Current levels	Current area	Current condition	Current condition	Current level
	Desired effect	Low or no numbers of brook trout left	Lower summer and higher winter temperatures	Increase in the area that juvenile fish hold in critical periods	Long term trend of reduced rates of deposition	Reduce (or no increase) in current levels	More instream flow	More riparian area	More fish habitat	Increased cover and resting areas	Reduced or none

E = Effectiveness; S/T = status/trend monitoring

Table 29. Data information and archive

		Reduce or eliminate brook trout	***Moderate summer and winter temperature***	***Identify summer and winter refugia***	***Reduce sediment***	***Determine contaminant levels***	***Reduce impacts of water withdrawal***	***Increase riparian area and function***	***Increase off - channel habitat***	***Increase in-channel diversity and structure***	***Reduce poaching and harassment***
Quality Assurance/ control	Agency responsible for developing QA/QC	USFWS, WDFW, YN	DOE, YN	USFWS, WDFW, YN	USFS, YN	DOE, YN	DOE, YN	EPU, YN	WDFW, YN	WDFW, YN	WDFW, YN
Data management	Format	PDA in field	PDA in field	PDA in field	PDA in field	PDA in field	PDA in field	PDA in field	PDA in field	PDA in field	n.a.
	Stored	To be determined	To be determined	To be determined	To be determined	To be determined	To be determined	To be determined	To be determined	To be determined	n.a.
	Updated	2 x/yr	2 x/yr	2 x/yr	2 x/yr	2 x/yr	2 x/yr	2 x/yr	2 x/yr	2 x/yr	2 x/yr
	Access	Updates, Drafts, website	Updates, Drafts, website	Updates, Drafts, website	Updates, Drafts, website	Updates, Drafts, website	Updates, Drafts, website	Updates, Drafts, website	Updates, Drafts, website	Updates, Drafts, website	n.a.
Report preparation	Format	Technical memo.	Formal report	Formal report	Formal report	Formal report	Formal report	Formal report	Formal report	Formal report	Update memo.
	Presentation	Updates, final	Updates, final	Updates, final	Updates, final	Updates, final	Updates, final	Updates, final	Updates, final	Updates, final	Updates
	Incorporation of comments	After sent to regional biologists for input	After sent to regional biologists for input	After sent to regional biologists for input	After sent to regional biologists for input	After sent to regional biologists for input	After sent to regional biologists for input	After sent to regional biologists for input	After sent to regional biologists for input	After sent to regional biologists for input	Continuously

Table 30. Evaluation

		Reduce or eliminate brook trout	Moderate summer and winter temperature	Identify summer and winter refugia	Reduce sediment	Determine contaminant levels	Reduce impacts of water withdrawal	Increase riparian area and function	Increase off - channel habitat	Increase in-channel diversity and structure	Reduce poaching and harassment
Scientific	Strength	If successful, can increase productivity of focal species	Modifying temperatures may increase survival of focal species through various life stages	Identifying summer ad winter refugia will increase managers' knowledge on habitat features that should be developed or preserved.	Many of the habitat conditions that need to be restored or fixed will do more than just reduce sediment depositional rate.	Toxin levels within fish will be an indicator of pesticide and herbicide movement through the environ-ment	Increased efficiency of water use will have many benefits for fish and wildlife species, and potentially for irrigators.	Increases in riparian area can have immediate impacts on fish and wildlife, and long term impacts on habitat improvement.	Increased off channel habitat will have immediate benefits for focal species, especially late-run Chinook.	Increase in-channel habitat will have long term benefits to fish through all life stages.	Reduced poaching should increase the number of spawning adults of the various focal species.
	Weaknesss	Brook trout are established in many areas within the subbasin and eliminating them will be difficult	Temperature is naturally limiting within the subbasin. Attempts may be futile.	Data may be highly variable between years.	The outcome of the proposed actions may take years and years before any benefit is seen (and it may be difficult to show cause and effect).	Factors regulating the use of pesticides and herbicides may not decrease the uptake of toxins by fish for many years	Water use is complicated and increases in efficiency may be costly.	Restoring riparian areas is difficult because of current land use practices and natural events that might decrease the project's success.	Finding appropriate sites in areas that it is needed is difficult because of current land use practices.	Historically, man made in-channel projects have a high rate of failure.	Unless enforce-ment is increased, or "watchdog groups" are formed, tracking and reducing poaching is futile.
Decision-making	Determine if alternatives should be needed	If the removal program proves to be ineffective	After monitoring suggests that there is nothing that can be done	If evaluations suggests that refugia cannot be found	If proposed actions are not feasible.	If no toxins are found within a representative sample	After feasibility studies and other efforts do not identify mutually agreed upon alternatives.	If proposed actions are not feasible.	If proposed actions are not feasible.	If proposed actions are not feasible.	If local groups are not involved.

	Management response to changes in indicators	Pursue comments, collaborate, and determine other approaches	Focus on other limiting factors	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches	Pursue comments, collaborate, and determine other approaches
Public	Review format	Advertise web page where draft info is available then presentation	Advertise web page where draft info is available then presentation	Advertise web page where draft info is available then presentation	Advertise web page where draft info is available then present-ation	Advertise web page where draft info is available then present-ation	Advertise web page where draft info is available then presentation	Advertise web page where draft info is available then presentation	Advertise web page where draft info is available then present-ation	Advertise web page where draft info is available then present-ation	Advertise web page where draft info is available then present-ation
	Comment format	Written, verbal @ presentation	Written, verbal @ presentation	Written, verbal @ presentation	Written, verbal @ presentation	Written, verbal @ presentation	Written, verbal @ presentation	Written, verbal @ presentation	Written, verbal @ present-ation	Written, verbal @ present-ation	Written, verbal @ present-ation
	Incorporate comments	Lead agency	Lead agency	Lead agency	Lead agency	Lead agency	Lead agency	Lead agency	Lead agency	Lead agency	Lead agency

7.8 Terrestrial

7.8.1 Introduction

The process used to develop wildlife assessments and management plan objectives and strategies is based on the need for a landscape level holistic approach to protecting the full range of biological diversity at the Ecoregion scale with attention to size and condition of core areas (subbasin scale), physical connections between core areas, and buffer zones surrounding core areas to ameliorate impacts from incompatible land uses. As most wildlife populations extend beyond subbasin or other political boundaries, this "conservation network" must contain habitat of sufficient extent, quality, and connectivity to ensure long-term viability of obligate/focal wildlife species. Subbasin planners recognized the need for large-scale planning that would lead to effective and efficient conservation of wildlife resources.

In response to this need, Ecoregion planners approached subbasin planning at two scales. The landscape scale emphasizes focal habitats and associated species assemblages that are important to Ecoregion wildlife managers while specific focal habitat and/or species needs are identified at the subbasin level.

Ecoregion and subbasin planners agreed with Lambeck (1997) who proposed that species requirements (umbrella species concept) could be used to guide ecosystem management. The main premise is that the requirements of a demanding species assemblage encapsulate those of many co-occurring less demanding species. By directing management efforts toward the requirements of the most exigent species, the requirements of many cohabitants that use the same habitat type are met. Therefore, managing habitat conditions for a species assemblage should provide life requisite needs for most other focal habitat obligate species.

Ecoregion/subbasin planners also assumed that by focusing resources primarily on riparian wetland, ponderosa pine, and shrub-steppe habitats, the needs of most listed and managed terrestrial species dependent on these habitats would be addressed during this planning period. While other listed and managed species occur within the subbasin, primarily forested habitat obligates, needs of these species are addressed primarily through the existing land management frameworks of the federal agencies within whose jurisdiction the overwhelming majority of these habitats occur within the Entiat subbasin (primarily, Entiat National Forest).

Ecoprovince/subbasin planners identified a focal species assemblage for each focal habitat type and combined life requisite habitat attributes for each species assemblage to form a "recommended range of management conditions", that, when achieved, should result in functional habitats. The rationale for using focal species assemblages is to draw immediate attention to habitat features and conditions most in need of conservation or most important in a functioning ecosystem. The corollary is that factors that affect habitat quality and integrity within the Ecoregion and subbasins also impact wildlife species. As a result, identifying and addressing "factors that affect focal habitats" should support the needs of obligate wildlife populations as well. Planners recognize, however, that addressing factors that limit habitat does not necessarily address some anthropogenic induced limiting factors such as affects of human presence on wildlife species.

Emphasis in this management plan is placed on the selected focal habitats and wildlife species described in the inventory and assessment. It is clear from the inventory and assessment that reliable quantification of most subbasin level impacts is lacking, however, many anthropogenic changes have occurred and clearly impact the focal habitats: riparian wetlands, shrub-steppe and ponderosa pine forest habitats. While all habitats are important, focal habitats were selected in part because they are disproportionately vulnerable to anthropogenic impacts, and likely have received the greatest degree of existing impacts within the subbasin. In particular, the majority of shrub-steppe and ponderosa pine habitats fall within the low or no protection status categories defined above. Some of the identified impacts are, for all practical purposes, irreversible (conversion to urban and residential development, primary transportation systems); others are already being mitigated through ongoing management (i.e., USFS adjustments to grazing management).

It is impractical to address goals for future conditions within the subbasin without consideration of existing conditions; not all impacts are reversible. The context within which this plan was drafted recognizes that human uses do occur, and will continue into the future. Recommendations are made within this presumptive framework.

7.8.2 Vision

Natural habitats exist with sufficient quantity, quality and linkages to perpetuate existing native wildlife populations into the foreseeable future. Where sufficient habitat exists, through a combination of protection and restoration, extirpated wildlife species are restored within the subbasin.

7.8.3 Biological Goals, Objectives, and Strategies

The overall goal is for natural habitats to exist with sufficient quantity, quality and linkages to perpetuate existing native wildlife populations into the foreseeable future. Where sufficient habitat exists, through a combination of protection and restoration, extirpated wildlife species will be restored within the subbasin.

Shrubsteppe

Goal

Provide sufficient quantity and quality shrubsteppe habitat to support the diversity of wildlife as represented by sustainable focal species populations. Emphasis should be placed on managing sagebrush-dominated shrub-steppe toward conditions 1 and 2 identified in 3.1.7.2.3.1 (Inventory and Assessment).

Habitat Objective 1

Determine the necessary amount, quality, and juxtaposition of shrubsteppe by the year 2008.

- Strategy: Select and implement methodology, alternative to IBIS or GAP, to accurately characterize shrubsteppe habitat in the Entiat subbasin.

Habitat Objective 2

Based on findings of Objective 1, identify and provide biological and social conservation measures to sustain focal species populations and habitats by 2010.

- Strategy: Utilize federal, state, tribal, and local government programs, such as USDA “Farm Bill” programs, to conserve shrubsteppe habitat.
- Strategy: Achieve permanent protection of shrubsteppe through acquisition, conservation easement, cooperative agreements, etc.
- Strategy: Emphasize conservation of large blocks and connectivity of high quality shrubsteppe habitat.
- Strategy: Promote local planning and zoning to maintain or enhance large blocks of habitat.

Habitat Objective 3

Maintain and/or enhance habitat function (i.e., focal habitat attributes) by improving agricultural practices, fire management, weed control, livestock grazing practices, and road management on existing shrubsteppe.

- Strategy: Implement habitat stewardship projects with private landowners.
- Strategy: Develop fire management protocols (protection and prescribed burning) to produce desired shrubsteppe habitat conditions.
- Strategy: Entiat National Forest plan, Chelan County Watershed Mgt Plan, WDFW Wildlife Area Management Plan, Yakama Nation Tribal Restoration Plan, Colville Tribes Integrated Resource Management Plan.
- Strategy: Develop and implement a coordinated, cross-jurisdictional comprehensive weed control management plan.
- Strategy: Develop and implement a coordinated, cross-jurisdictional road management plan.

Biological Objective 1

Determine population status of Brewer’s sparrow by 2008.

Strategy: Select survey protocol and measure abundance of focal species.

Strategy: Select survey protocol and measure diversity and richness of species assemblages within shrub-steppe.

Biological Objective 2

Within the framework of the Brewer’s sparrow population status determination, inventory other shrub-steppe obligate populations to test assumption of the umbrella species concept for conservation of other shrub-steppe obligates.

Strategy: Implement federal, state, tribal management and recovery plans.

Biological Objective 3:

Maintain and enhance mule deer populations consistent with state/tribal herd management objectives.

Strategy: Implement state and tribal management plans.

Strategy: Ensure mule deer habitat needs are met on federal, state, and tribal managed lands during land use planning.

Strategy: Maintain mule deer populations within private landowner tolerances.

Ponderosa Pine

Goal

Provide sufficient quantity and quality ponderosa pine habitats to support the diversity of wildlife as represented by sustainable focal species populations. Emphasis should be placed on managing ponderosa pine toward conditions 1a, 1b, 2 and 3 identified in 3.1.7.1.3 (Inventory and Assessment).

Habitat Objective 1

Determine the necessary amount, quality, and juxtaposition of ponderosa pine habitats by the year 2008.

- Strategy: Select and implement methodology, alternative to IBIS or GAP, to accurately characterize ponderosa pine habitat in the Entiat subbasin.

Habitat Objective 2

Based on findings of Objective 1, provide biological and social conservation measures to sustain focal species populations and habitats by 2010.

- Strategy: Utilize federal, state, tribal, and local government programs to conserve ponderosa pine habitat.
- Strategy: Achieve permanent protection of ponderosa pine through acquisition, conservation easement, cooperative agreements, etc.
- Strategy: Emphasize conservation of large blocks and connectivity of high quality ponderosa pine habitat.
- Strategy: Promote local planning and zoning to maintain or enhance large blocks of habitat.

Habitat Objective 3

Maintain and/or enhance habitat function (i.e., focal habitat attributes) by improving silvicultural practices, fire management, weed control, livestock grazing practices, and road management in existing and restored ponderosa pine habitat.

Strategy: Implement habitat stewardship projects with private landowners.

Strategy: Develop fire management protocols (protection and prescribed burning) to produce desired ponderosa pine habitat conditions.

Strategy: Entiat National Forest plan, Chelan County Watershed Mgt Plan, WDFW Wildlife Area Management Plan, Yakama Nation Tribal Restoration Plan, Colville Tribes Integrated Resource Management Plan.

- Strategy: Develop and implement a coordinated, cross-jurisdictional comprehensive weed control management plan.
- Strategy: Develop and implement a coordinated, cross-jurisdictional road management plan.

Biological Objective 1:

Determine population status of white-headed woodpecker, flammulated owl, and pygmy nuthatch by 2008.

- Strategy: Select survey protocol and measure abundance of focal species.
- Strategy: Select survey protocol and measure diversity and richness of species assemblages within ponderosa pine.

Biological Objective 2

Within the framework of the focal species population status determinations, inventory other ponderosa pine obligate populations to test assumption of the umbrella species concept for conservation of other ponderosa pine obligates.

- Strategy: Implement federal, state, tribal management and recovery plans.

Riparian Wetlands

Goal

Provide sufficient quantity and quality riparian wetlands to support the diversity of wildlife as represented by sustainable focal species populations. Emphasis should be placed on managing riparian wetland habitats toward conditions 1a, 1b, and 2 identified in 3.1.7.3.3 (Inventory and Assessment).

Habitat Objective 1

Determine the necessary amount, quality, and connectivity of riparian wetlands by the year 2008.

- Strategy: Select and implement methodology, alternative to IBIS or GAP, to accurately characterize riparian wetlands habitats in the Entiat subbasin.

Habitat Objective 2

Based on findings of Habitat Objective 1, provide biological and social conservation measures to sustain focal species populations and habitats by 2010.

- Strategy: Utilize federal, state, tribal, and local government programs, to conserve riparian wetlands habitat.

- Strategy: Achieve permanent protection of riparian wetlands through acquisition, conservation easement, cooperative agreements, etc.
- Strategy: Emphasize conservation connectivity of high quality riparian wetlands habitat.
- Strategy: Promote local planning and zoning to maintain or enhance riparian wetlands habitat.

Habitat Objective 3

Maintain and/or enhance habitat function (i.e., focal habitat attributes) by improving silviculture, agricultural practices, fire management, weed control, livestock grazing practices, and road construction and maintenance on and adjacent to existing riparian wetlands.

- Strategy: Implement habitat stewardship projects with private landowners.
- Strategy: Develop fire management protocols (protection and prescribed burning) to produce desired riparian wetlands habitat conditions.
- Strategy: Entiat National Forest plan, Chelan County Watershed Mgt Plan, WDFW Wildlife Area Management Plan, Yakama Nation Tribal Restoration Plan, Colville Tribes Integrated Resource Management Plan.
- Strategy: Develop and implement a coordinated, cross-jurisdictional comprehensive weed control management plan.
- Strategy: Develop and implement a coordinated, cross-jurisdictional road management plan.

Biological Objective 1

Determine population status of beaver, red-eyed vireo, and yellow-breasted chat by 2008.

- Strategy: Select survey protocol and measure abundance of focal species.
- Strategy: Select survey protocol and measure diversity and richness of species assemblages within riparian wetland habitats.

Biological Objective 2

Within the framework of the focal species population status determinations, inventory other riparian wetlands obligate populations to test assumption of the umbrella species concept for conservation of other riparian wetlands obligates.

- Strategy: Implement federal, state, tribal management and recovery plans.

Biological Objective 3

Based on findings of Biological Objective 1 and Habitat Objective 2, maintain and enhance beaver populations where appropriate and consistent with state/tribal management objectives.

- Strategy: Protect, and where necessary restore, habitat to support beaver.
- Strategy: Reintroduce beaver into suitable habitat where natural recolonization may not occur.
- Strategy: Through state harvest restrictions, protect beaver populations at a level sufficient to allow natural and reintroduced beaver populations to perpetuate at levels that will meet Habitat Objective 2.

7.8.4 Research, Monitoring, and Evaluation Plan

The Research, Monitoring, and Evaluation (RME) plan for the subbasin is intended as a tool that will allow managers to evaluate the efficacy of employed strategies in achieving corresponding focal habitat objectives for the subbasin. If implemented, elements of the plan will also facilitate coordination and tracking of management activities within the subbasin, periodic review of progress, and a basis for recommended adjustments to management direction over time (adaptive management).

The RME plan, as presented, consists of a variety of quantitative elements, ranging from scientific wildlife and vegetation surveys, spatial analyses of project location and acreage, to simple enumeration of land use projects/regulations commented upon by cooperating agencies.

Organization of the RME plan is as follows:

Research

- Research needs, with justification, are also listed. Detailed research project design is not presented, however, being beyond the scope of the current planning effort
- Existing Data Gaps, as identified through the subbasin planning process, are listed in this section, because many will require effort above routine monitoring and evaluation to address

Monitoring and Evaluation

- Focal habitat monitoring methodology, and Management Plan strategies addressed
- Focal species monitoring methodology, and Management Plan strategies addressed

7.8.5 Existing Data Gaps and Research Needs

In the course of subbasin plan development, a number of data gaps were identified. Some of these gaps will be filled as data is collected via the monitoring and evaluation process as the plan is implemented. Others will require formal research efforts to address. Data gaps and research needs identified during development of the subbasin plan are listed in Table 31.

As part of the adaptive management philosophy of subbasin planning, managers believe that additional research needs not yet identified will become apparent over time. These needs should be addressed in future subbasin plan iterations.

Table 31. Data gaps and research needs, Entiat subbasin, as identified during subbasin planning

RESEARCH NEEDS AND DATA GAPS	STRATEGY TO ADDRESS	AGENCY/ PERSONNEL
GENERAL		
Testing of assumption that focal habitats are functional if a focal species assemblage's recommended management conditions are achieved		Coordinated government & NGO effort
Testing of assumption that selected species assemblages adequately represent focal habitats		Coordinated government & NGO effort
Current, broad-scale habitat data	Spatial data collection and GIS analysis	Coordinated government & NGO effort
RIPARIAN WETLANDS		
Research Needs, recommended priority order		
Refinement of recommended management conditions for Riparian Wetlands	Research need; use for update to future subbasin plan iterations	Coordinated government & NGO effort.
Data are needed on all aspects of red-eyed vireo, yellow-breasted chat and beaver ecology in the subbasin.		Coordinated government & NGO effort
Data Gaps		
Accurate habitat type maps are needed to improve assessment quality and support management strategies and actions, including, updated and fine resolution historic/current riparian wetland data and GIS products e.g., structural conditions and KEC ground-truthed maps	Coordinated, standardized monitoring efforts; Spatial data collection and GIS analysis	Subbasin managers
Riparian habitat quality data. Assessment data do not address habitat quality.	Monitoring activities	Subbasin managers
Refined habitat type maps	Spatial data collection and GIS analysis	Subbasin managers
GIS soils products including wetland delineations	Spatial data collection and GIS analysis	Subbasin managers
Local population/distribution data for red-eyed vireo, yellow-breasted chat, and beaver	Species Monitoring, Spatial data collection, and GIS analysis	WDFW, Subbasin managers
PONDEROSA PINE		
Research Needs, recommended priority order		
Data are needed on all aspects of white-headed woodpecker nesting ecology and habitat use within the Entiat subbasin		Coordinated government & NGO effort
Data are needed on all aspects of pygmy nuthatch nesting ecology and habitat use within the Entiat subbasin		Coordinated government & NGO effort
Data are needed on all aspects of flammulated owl nesting		Coordinated government

RESEARCH NEEDS AND DATA GAPS	STRATEGY TO ADDRESS	AGENCY/ PERSONNEL
ecology and habitat use, specifically related to the size, configuration, and abundance of grassy openings for foraging and clumped thickets of sapling/pole trees for roosting		& NGO effort
Research to determine if restored sites attract white-headed woodpeckers and provide viable habitat, to include recommendations on effective treatment conditions		Coordinated government & NGO effort
Research to determine if restored sites attract pygmy nuthatches and provide viable habitat, to include recommendations on effective treatment conditions		Coordinated government & NGO effort
Research to determine whether an intensively harvested landscape that meets snag and large tree objectives support viable white-headed woodpecker populations		Coordinated government & NGO effort
Research to determine whether a managed site attracts flammulated owls and provides viable habitat. Identification of the most effective treatment processes and conditions most effective.		Coordinated government & NGO effort
Data Gaps		
Refinement of recommended management conditions for Ponderosa pine: collect current ponderosa pine structural condition/habitat variable data	Management Objective for Ponderosa pine	Subbasin managers
Accurate habitat type maps are needed to improve assessment quality and support management strategies and actions, including, updated and fine resolution historic/current ponderosa pine data and GIS products e.g., structural conditions and KEC ground-truthed maps	Coordinated, standardized monitoring efforts; Spatial data collection and GIS analysis	Subbasin managers
Habitat quality data. Assessment data do not address habitat quality.	Coordinated, standardized monitoring efforts); Spatial data collection and GIS analysis	Subbasin managers
Finer resolution GIS habitat type maps that include structural component and KEC data.	Coordinated, standardized monitoring efforts); Spatial data collection and GIS analysis	Subbasin managers
GIS soils products	Spatial data collection and GIS analysis	Subbasin managers
Identify current distribution and population levels of white-headed woodpeckers, pygmy nuthatches and flammulated owls	Species Monitoring, Spatial data collection, and GIS analysis	WDFW, Subbasin managers
Identify current and potential areas of high quality flammulated owl habitat (short-term strategy i.e., <2 years).	Habitat Monitoring, Spatial data collection, and GIS analysis	WDFW, Subbasin managers
Monitor white-headed woodpecker, pygmy nuthatch and flammulated owl distributions within the Entiat subbasin, to determine current distributions, population levels and population	Species Monitoring, Spatial data collection, and GIS analysis	WDFW, Subbasin managers

RESEARCH NEEDS AND DATA GAPS	STRATEGY TO ADDRESS	AGENCY/ PERSONNEL
trends		
SHRUBSTEPPE		
Research Needs, recommended priority order		
Data are needed on all aspects of Brewer's sparrow nesting ecology, especially area requirements to maintain populations		WDFW, Subbasin managers
Data are needed on all aspects of Brewer's sparrow nesting ecology, particularly relationship to livestock grazing and pesticide use		WDFW, Subbasin managers
An assessment of the viability of small populations of Brewer's sparrow in fragments of habitat versus those in large contiguous blocks		WDFW, Subbasin managers
Data Gaps		
Accurate habitat type maps are needed to improve assessment quality and support management strategies and actions, including, updated and fine resolution historic/current shrubsteppe data and GIS products e.g., structural conditions and KEC ground-truthed maps	Coordinated, standardized monitoring efforts; Spatial data collection and GIS analysis	Subbasin managers
Habitat quality data. Assessment data bases do not address habitat quality	Coordinated, standardized monitoring efforts; Spatial data collection and GIS analysis	Subbasin managers
Refined habitat type maps	Coordinated, standardized monitoring efforts; Spatial data collection and GIS analysis	Subbasin managers
GIS soils products, including wetland delineations	Spatial data collection and GIS analysis	Subbasin managers
Local population/distribution distribution for Brewer's sparrow	Species Monitoring, Spatial data collection, and GIS analysis	WDFW, Subbasin managers
Monitor Brewer's sparrow distribution within the Entiat subbasin, to determine current distribution, population level and population trends	Species Monitoring, Spatial data collection, and GIS analysis	WDFW, Subbasin managers
Evaluate the role of fire, mowing, and other management treatments to maintain/improve shrupsteppe habitat quality	Coordinated, standardized monitoring efforts	Subbasin managers

7.8.6 Monitoring and Evaluation

Focal Habitat and Species monitoring methodology

Recommended monitoring and evaluation strategies contained below for each focal habitat type, including sampling and data analysis and storage, are derived from national standards established by Partners in Flight for avian species (Ralph et al, 1993, 1995) and habitat monitoring (Nott et al, 2003). Deer sampling methodology follow standard protocols established by the Washington Department of Fish and Wildlife. In addition, protocols for specific vegetation monitoring/sampling methodologies are drawn from USDA Habitat Evaluation Procedure standards (USFWS 1980a and 1980b). A common thread in the monitoring strategies which follow is the establishment of permanent census stations to monitor bird population and habitat changes.

Wildlife managers will include statically rigorous sampling methods to establish links between habitat enhancement prescriptions, changes in habitat conditions and target wildlife population responses.

Specific methodology for selection of Monitoring and Evaluation sites within all focal habitat types follows a probabilistic (statistical) sampling procedure, allowing for statistical inferences to be made within the area of interest. The following protocols describe how M&E sites will be selected (from WDFW response to ISRP http://www.cbfwa.org/files/province/cascade/projects/199609400resp.pdf):

- Vegetation/HEP monitoring and evaluation sites are selected by combining stratified random sampling elements with systematic sampling. Project sites are stratified by cover types (strata) to provide homogeneity within strata, which tends to reduce the standard error, allows for use of different sampling techniques between strata, improves precision, and allows for optimal allocation of sampling effort resulting in possible cost savings (Block et al. 2001). Macro cover types such as shrub-steppe and forest are further sub-cover typed based on dominant vegetation features i.e., percent shrub cover, percent tree cover, and/or deciduous versus evergreen shrubs and conifer versus deciduous forest. Cover type designations and maps are validated prior to conducting surveys in order to reduce sampling inaccuracies.

- Pilot studies are conducted to estimate the sample size needed for a 95% confidence level with a 10% tolerable error level (Avery 1975) and to determine the most appropriate sampling unit for the habitat variable of interest (BLM 1998). In addition, a power analysis is conducted on pilot study data (and periodically throughout data collection) to ensure that sample sizes are sufficient to identify a minimal detectable change of 20% in the variable of interest with a Type I error rate of not more than 0.10 and $P = 0.9$ (BLM 1998, Hintze 1999, Block et al. 2001). M&E includes habitat trend condition monitoring on the landscape scale (Tier 1-HEP) and plant community monitoring (Tier 2) i.e., measuring changes in vegetative communities on specific sites.

- For HEP surveys, specific transect locations within strata are determined by placing a Universal Transverse Mercator (UTM) grid over the study area (strata) and randomly selecting “X” and “Y” coordinates to designate transect start points. Random transect azimuths are chosen from a computer generated random number program, or from a standard random number table. Data points and micro plots are systematically placed along the line intercept transect at assigned intervals as described in Part 2 – monitoring section of the proposal. Sample sizes for statistical inferences are determined by replication and systematic placement of lines of intercept within the strata with sufficient distance between the lines to assume independence and to provide uniform coverage over the study site.

- Permanent vegetation monitoring transect locations are determined by placing a UTM grid over the strata and randomly selecting “X” and “Y” coordinates to designate plot locations as described for HEP surveys. One hundred meter baseline transect azimuths are randomly selected from a random numbers table. Ten perpendicular 30 meter transects are established at 10 meter intervals along the baseline transect to form a 100m x 30m rectangle (sample unit). Micro plot and shrub intercept data are collected at systematic intervals on the perpendicular transects.

By systematically collecting and analyzing plant species frequency, abundance, density, height, and percent cover data, vegetative trends through time can be described. Likewise, the effectiveness of exotic weed control methods can be evaluated and weed control plans can be adjusted accordingly.

Presence of all exotic weeds i.e., knapweeds, yellow starthistle, etc. will be mapped in GIS using Global Positioning System (GPS) equipment. This information will be used to develop an annual exotic vegetation control plan.

Causes of seeding or planting failure will be identified and planting methods/site preparation will be modified as necessary. Data will be collected and analyzed, and, where necessary, changes in the management plan (adaptive management) will be identified and implemented.

General and site specific M&E protocols, outlining monitoring goals and objectives and specific sampling designs are included in the following monitoring section.

In addition to defining habitat and species population trends, monitoring will also be used to determine if management actions have been carried out as planned (implementation monitoring). In addition to monitoring plan implementation, monitoring results will be evaluated to determine if management actions are achieving desired goals and objectives (effectiveness monitoring) and to provide evidence supporting the continuation of proposed management actions. Areas planted to native shrubs/trees and/or seeded to herbaceous cover will be monitored twice a year to determine shrub/seeding survival, and causes of shrub mortality and seeding failure i.e. depredation, climatic impacts, poor site conditions, poor seed/shrub sources.

Monitoring of habitat attributes and focal species in this manner will provide a standardized means of tracking progress towards conservation, not only within the Entiat subbasin, but within a national context as well. Monitoring will provide essential feedback for demonstrating adequacy of conservation efforts on the ground, and guide the adaptive management component that is inherent in the subbasin planning process.

7.8.7 Riparian Wetlands

Focal Species

Red-eyed vireo (*Vireo olivaceous*), yellow-breasted chat (*Icteria virens*), and American Beaver (*Castor canadensis*)

Overall Habitat and Species Monitoring Strategy: Establish monitoring program for protected and managed Riparian Wetland sites to monitor focal species population and habitat changes and evaluate success of efforts.

Overall Habitat and Species Monitoring Strategy: Establish permanent censusing stations to monitor bird population and habitat changes.

Focal Habitat Monitoring

Factors affecting habitat: 1.) Direct loss of riparian deciduous and shrub understory, 2.) Fragmentation of wetland habitat, 3.) agricultural and sub-urban development and disturbance, 4.) reduction in water quality, 5.) organochlorines such as dieldrin or DDE may cause thinning in egg shells which results in reproductive failure (Graber et al. 1978; Ohlendorf et. al. 1980; Konermann et. al. 1978) (Sec. 5.2.3.3.6).

Riparian Wetlands Working Hypothesis Statement

The proximate or major factors affecting this focal habitat type are direct loss of habitat due primarily to urban/agricultural development, reduction of habitat diversity and function resulting from exotic vegetation, livestock overgrazing, fragmentation and recreational activities. The principal habitat diversity stressor is the spread and proliferation of invasive exotics. This coupled with poor habitat quality of existing vegetation have resulted in extirpation and or significant reductions in riparian habitat obligate wildlife species.

Recommended Range of Management Conditions

1. Well-distributed range of 20 to 100 percent tree canopy closure (cottonwood and other hardwood species), with a mature cottonwood component including trees at least 160 feet tall
2. Multi-structure/age tree canopy (includes trees less than 6 inches in diameter and mature/decadent trees)
3. Forty to 80 percent native shrub cover (greater than 50 percent comprised of hydrophytic shrubs), with scattered herbaceous openings
4. Multi-structured shrub canopy greater than 3 feet in height, at least 10% of which are comprised of young cottonwoods

Focal Habitat Monitoring Strategies: Establish an inventory and long-term monitoring program for protected and restored riparian wetlands to determine success of efforts.

1. Identify riparian wetland sites within the subbasin that support populations of focal species for this habitat.
2. Evaluate habitat site potential on existing public lands and adjacent private lands for protection. (short-term strategy i.e., < 2 years).
3. Enhance habitat on public lands and adjacent private lands.
4. Identify high quality/functional privately owned riparian wetlands sites that are not adjacent to public lands (long-term strategy 2 to 15 years).

5. Establish permanent censusing stations to monitor bird population and habitat changes

Sampling Design

HEP is a standardized habitat-analysis strategy developed by the U.S. Fish and Wildlife Service. It uses a variety of Habitat Suitability Indices (HSI) for select wildlife species to evaluate the plant community as a whole (Anderson and Gutzwiller 1996). Sites are stratified by cover type, and starting points are established using a random number grid. Minimum length of a HEP transect is 600 ft, and patches of cover must be large enough to contain a minimum transect without extending past a 100 foot buffer inside the edge of the cover type. (Riparian zone width within portions of the subbasin will require modification of this 100 foot buffer requirement.)

In addition, at any permanently established avian species monitoring site established within the Riparian Wetland habitat, structural habitat conditions will be monitored every 5 years as per Habitat Structure Assessment protocol (Nott et al 2003).

Sampling Methods (USFWS 1980a and 1980b):

1. Herbaceous measurements are taken every 20 ft. on the right side of the tape (the right is always determined by standing at 0 ft and facing the line of travel). The sampling quadrant is a rectangular 0.5m2 microplot, placed with the long axis perpendicular to the tape, and the lower right corner on the sampling interval.

2. Shrub canopy cover is measured using a point intercept method and is visually estimated before starting each transect. If the total shrub cover is anticipated to be >20%, shrub data are collected every 5 ft (20 possible "hits" per 100 ft segment). If shrub canopy cover is anticipated to be <20%, data are collected every 2 ft (50 possible "hits" per 100 ft segment).

Shrub height measurements are collected on the tallest part of a shrub that crosses directly above each sampling intercept mark. For shorter shrub classifications (i.e. all shrubs less than 3 feet), the tallest shrub is measured that falls within that category.

3. Tree canopy cover measurements are taken every ten feet along a transect. Basal and snag measurements are taken within a tenth-acre circular plot at the end of each 100 ft segment. The center point of the circular plot is the 100 ft mark of the transect tape, and the radius of the circle is 37.2 ft.

In addition, at any permanently established avian species monitoring site established within the Riverine Wetland habitat, structural habitat conditions will be monitored every 5 years as per Habitat Structure Assessment protocol (Nott et al 2003) (http://www.birdpop.org/DownloadDocuments/manual/HSAManual03.PDF).

Analysis: Transects are divided into 100 ft. segments, and total transect length is determined using a "running mean" to estimate variance (95% probability of being within 10% of the true mean).

Sample size equation: n = t2 x s2

E2

Where: t = value at 95 percent confidence interval with suitable degrees of freedom

s = standard deviation

E = desired level of precision, or bounds

Focal Species Monitoring

Beaver, yellow-breasted chat and red-eyed vireo

Rationale: Maintaining and enhancing beaver, yellow-breasted chat and red-eyed vireo populations within the subbasin will assure the maintenance and rehabilitation of riparian wetlands.

Limiting Factors

1) Loss of deciduous tree cover and sub-canopy/shrub habitat in riparian zones. 2.) Conversion of riparian habitat due to channelization, agriculture, and development, 3) flooding of habitat resulting from hydropower facilities, 4) habitat fragmentation, 5) degradation of existing habitats from overgrazing and introduced weedy vegetation, and 6) tree/shrub removal in riparian areas. Proximity to agriculture, suburban development creates a hostile landscape where a high density of nest parasites, such as, brown cowbird and predation by domestic cats may occur. Disturbance from agriculture, silviculture, road management and recreational activities can also cause nest abandonment.

Assumptions: 1) Addressing factors that affect riparian wetlands, will also address red-eyed vireo, beaver and other wetland obligate species limiting factors. 2) If riparian wetland habitat is of sufficient quality, extent, and distribution to support viable yellow-breasted chat, red-eyed vireo and beaver populations, the needs of most other riparian wetland obligate species will also be addressed and habitat functionality could be inferred. 3) If habitat is present sufficient to support avian focal species, suitable habitat will be present to support beaver. 4) Beaver will persist in these habitats if appropriate protection measures to preclude overharvest are implemented.

Sampling Strategy: Survey points will be placed among habitat types of interest using a stratified random design. Number of survey points in each habitat type will be determined using power analysis with the goal of being able to detect a 25% increase in abundance of yellow warbler with a power of 0.8 or greater. This protocol is based on the point count survey (Ralph et al. 1993, Ralph et al. 1995), with each survey station referred to as a "point count station." In addition to these bird survey data, information about the distance at which individual birds are detected will also be collected, allowing absolute density estimated to be made using distance-sampling methodology (e.g., the program DISTANCE).

Methods: We will survey birds on randomly selected (stratified) points along the riparian corridor. Each site will have 4 100-m fixed-radius point counts (Ralph et al. 1993) established along a transect and spaced 200m apart (Fig 4). Each point will be marked with a permanent fiberglass stake (1m electric fence post) and colored flagging will be placed on shrubs at 50 and 100m from the point in each of the 4 cardinal directions to aid in determining distance. Counts at each point will be 5 minutes in duration during which all birds seen or heard will be noted, along with their sex (if known), distance from the point (within 50m, >50 but <100m, or beyond 100m), and behavior (singing, calling, silent, or flying over the site). Surveys will be conducted once each in May and June and within prescribed weather parameters (e.g., no rain and low wind).

Analysis: Analysis is described by Nur et al. (1999). Absolute density estimation (see Buckland et al. 1993) can be estimated using the program DISTANCE, a free program available on the World-Wide Web (http://www.ruwpa.st-and.ac.uk/distance); an example is given in Nur et al. (1997). In brief: for species richness and species diversity, these can be analyzed as total species richness or as species richness for a subset of species; the same is true for species diversity. Species diversity can be measured using the Shannon index (Nur et al. 1999), also called the Shannon-Weiner or Shannon-Weaver index. Statistical analysis can be carried out using linear models (regression, ANOVA, etc.), after appropriate transformations (examples in Nur et al. 1999).

7.8.8 Ponderosa Pine

Focal Species

Flammulated owl (Otus flammeolus), white-headed woodpecker (Picoides albolarvatus), pygmy nuthatch (Sitta pygmaea)

Overall Habitat and Species Monitoring Strategy: Establish monitoring program for protected and managed Ponderosa pine sites to monitor focal species population and habitat changes and evaluate success of efforts.

Focal Habitat Monitoring

Factors affecting habitat

1. Direct loss old growth forest and associated large diameter trees and snags
2. Fragmentation of remaining Ponderosa pine habitat
3. Agricultural and sub-urban development and disturbance
4. Hostile landscapes which may have high densities of nest parasites, exotic nest competitors, and domestic predators
5. Fire suppression/wildfire
6. Overgrazing
7. Noxious weeds
8. Silvicultural practices
9. Insecticide use

Ponderosa Pine Working Hypothesis Statement: The near term or major factors affecting this focal habitat type are direct loss of habitat due primarily to timber harvesting, fire reduction/wildfires, mixed forest encroachment, development, recreational activities, reduction of habitat diversity and function resulting from invasion by exotic species and vegetation and overgrazing. The principal habitat diversity stressors are the spread and proliferation of mixed forest conifer species within ponderosa pine communities due primarily to fire reduction and intense, stand-replacing wildfires, and invasive exotic weeds. Habitat loss and fragmentation (including fragmentation resulting from extensive areas of undesirable vegetation) coupled with poor habitat quality of existing vegetation (i.e., lack of old growth forest and associated large diameter trees and snags) have resulted in significant reductions in ponderosa pine habitat obligate wildlife species.

Recommended Range of Management Conditions

Recognizing that extant ponderosa pine habitat within the subbasin currently covers a wide range of seral conditions, wildlife habitat managers have identified three general ecological / management conditions that, if met, will provide suitable habitat for multiple wildlife species at the subbasin scale within the ponderosa pine habitat type. These ecological conditions correspond to life requisites represented by a species' assemblage that includes white-headed woodpecker (Picoides albolarvatus), flammulated owl (Otus flammeolus), and pygmy nuthatch (Sitta pygmaea)

1. Mature ponderosa pine forest: The white-headed woodpecker represents species that require/prefer large patches (greater than 350 acres) of open mature/old growth ponderosa pine stands with canopy closures between 10 - 50 percent and snags (a partially collapsed, dead tree) and stumps for nesting (nesting stumps and snags greater than 31 inches DBH).
2. Multiple canopy ponderosa pine mosaic: Flammulated owls represent wildlife species that occupy ponderosa pine sites that are comprised of multiple canopy, mature ponderosa pine stands or mixed ponderosa pine/Douglas-fir forest interspersed with grassy openings and dense thickets. Flammulated owls nest in habitat types with low to intermediate canopy closure (Zeiner et al. 1990), two layered canopies, tree density of 508 trees/acre (9 foot spacing), basal area of 250 feet2/acre (McCallum 1994b), and snags greater than 20 inches DBH 3-39 feet tall (Zeiner et al. 1990). Food requirements are met by the presence of at least one snag greater than 12 inches DBH/10 acres and 8 trees/acre greater than 21 inches DBH.
3. Heterogeneous stands of ponderosa pine with a mixture of well-spaced, old pines and vigorous trees of intermediate age: pygmy nuthatches represent those species that depend on snags for nesting and roosting, high canopy density, and large diameter (greater than 18 inches DBH) trees characteristic of mature undisturbed forests. Connectivity between suitable habitats is important for species, such as pygmy nuthatch, whose movement and dispersal patterns are limited to their natal territories.

Focal Habitat Monitoring Strategies:

Establish an inventory and long-term monitoring program for protected and managed Ponderosa pine habitats to determine success of efforts. Subbasin managers recognize that restoration of late-successional forest is a long-term process, but these short-term (i.e., up to 15 years) strategies reflect the commitment and initiation of the process of management.

1. Identify Ponderosa pine habitat sites within the subbasin that support populations of focal species for this habitat.

2. Evaluate habitat site potential on existing public lands and adjacent private lands for protection of focal species habitat (short-term strategy i.e., < 2 years).
3. Enhance habitat on public lands and adjacent private lands (intermediate strategy; 2 to 10 years)
4. Identify high quality/functional privately owned Ponderosa pine sites that are not adjacent to public lands (long-term strategy 2 to 15 years).
5. Establish permanent censusing stations to monitor bird population and habitat changes.

Sampling Design: Permanent survey transects will be located within Ponderosa pine habitats using HEP protocols. HEP is a standardized habitat-analysis strategy developed by the U.S. Fish and Wildlife Service. It uses a variety of Habitat Suitability Indices (HSI) for select wildlife species to evaluate the plant community as a whole (Anderson and Gutzwiller 1996). Sites are stratified by cover type, and starting points are established using a random number grid. Minimum length of a HEP transect is 600 ft, and patches of cover must be large enough to contain a minimum transect without extending past a 100 foot buffer inside the edge of the cover type.

In addition, at any permanently established avian species monitoring site established within the Riverine Wetland habitat, structural habitat conditions will be monitored every 5 years as per Habitat Structure Assessment protocol (Nott et al 2003).

Sampling Methods (USFWS 1980a and 1980b):

1. Herbaceous measurements are taken every 20 ft. on the right side of the tape (the right is always determined by standing at 0 ft and facing the line of travel). The sampling quadrant is a rectangular 0.5m2 microplot, placed with the long axis perpendicular to the tape, and the lower right corner on the sampling interval.
2. Shrub canopy cover is measured using a point intercept method and is visually estimated before starting each transect. If the total shrub cover is anticipated to be >20%, shrub data are collected every 5 ft (20 possible "hits" per 100 ft segment). If shrub canopy cover is anticipated to be <20%, data are collected every 2 ft (50 possible "hits" per 100 ft segment).

Shrub height measurements are collected on the tallest part of a shrub that crosses directly above each sampling intercept mark. For shorter shrub classifications (i.e. all shrubs less than 3 feet), the tallest shrub is measured that falls within that category.

3. Tree canopy cover measurements are taken every ten feet along a transect. Basal and snag measurements are taken within a tenth-acre circular plot at the end of each 100 ft segment. The center point of the circular plot is the 100 ft mark of the transect tape, and the radius of the circle is 37.2 ft.

Measurement of Attributes (Habitat Conditions):

>10 snags/40 ha (>30cm DBH and 1.8m tall)

Method: A direct count in the 1/10 acre circle plot at the end of each 100 ft segment of the transect. DBH (measured with a loggers tape) and condition is noted for each snag. Snag condition scale follows Parks et al. (1997).

>20 trees /ha (>21” DBH)

Method: A direct count in the 1/10 acre circle plot. DBH measured with a logger’s tape.

Ponderosa Pine – old growth: >10 trees/ac (>21” DBH w/ >2 trees >31” DBH)

Method: A direct count in the 1/10 acre circle plot. DBH measured with a logger’s tape.

10-50% canopy closure

Method: A line intercept ‘hit’ or ‘miss’ measurement. Ten direct measurements along each 100 foot section of the transect (one every 10 feet) taken with a moosehorn densitometer.

> 1.4 snags/ac (>8” DBH w/ >50% >25”)

Method: A direct count in the 1/10 acre circle plot at the end of each 100 ft segment of the transect. DBH (measured with a loggers tape) and condition is noted for each snag. Snag condition scale follows Parks et al. (1997).

In addition, at any permanently established avian species monitoring site established within the ponderosa pine habitat, structural habitat conditions will be monitored every 5 years as per Habitat Structure Assessment protocol (Nott et al 2003).

Analysis: Transects are divided into 100 ft. segments, and total transect length is determined using a “running mean” to estimate variance (95% probability of being within 10% of the true mean).

Sample size equation: n = t2 x s2

E2

Where: t = value at 95 percent confidence interval with suitable degrees of freedom

s = standard deviation

E = desired level of precision, or bounds

Focal Species Monitoring

Flammulated Owl

Rationale: The Flammulated owl is listed as candidates for inclusion on the WDFW endangered species list and is considered a species-at-risk by the Washington GAP Analysis and Audubon-Washington. Flammulated owls are highly structurally dependent on the Ponderosa Pine habitat. Therefore, it is important to maintain and enhance the structure and function of ponderosa pine habitats for flammulated owls.

Limiting Factors: 1) Silvicultural practices that reduce habitat quality; 2) pesticide use; 3) predation/competitors; 4) exotics.

Assumptions: 1) Addressing factors that affect ponderosa pine, will also address flammulated owl and other ponderosa pine obligate species limiting factors. 2) If ponderosa pine habitat is of sufficient quality, extent, and distribution to support viable flammulated owl and white-headed woodpecker populations, the needs of most other ponderosa pine obligate species will also be addressed and ponderosa pine functionality could be inferred.

Sampling Strategy: The following methods are designed to, 1.) facilitate delineation of current distribution and population levels of flammulated owls, and; 2) identify current and potential areas of high quality flammulated owl habitat (short-term strategy i.e., <2 years).

Methods: Nighttime surveys will be conducted throughout potentially suitable Flammulated Owl breeding habitat, which will be determined according to habitat use reported in the literature, other reports, GIS habitat mapping, and other reported sightings the species.

Routes will be randomly selected from within the potential habitat area using a stratified sampling scheme. Each route should have between 10-12 stations, distributed along the route at equal intervals of .5 km, a standard methodology based on the distance owls can be heard on a calm night (at least 1.0 km) and the average size of territories (<500 m across) (Reynolds and Linkhart 1984, Howle and Ritchie 1987, Van Woudenberg and Christie 1997). The location of the starting point of the route, and of each station along the route, should be recorded as precisely as possible using a GPS (Global Positioning System). Each route should be surveyed three times per year during May-July – the time of year when vocal activity of the majority of species is greatest. Conduct surveys between 2200 and 0100 hours (Howle and Ritcey 1987, Groves et al. 1997). An attempt should be made to conduct the survey at the same time of night each year. At the beginning of the breeding season the greatest calling intensity for the Flammulated Owl is during much of the evening, and then after nestling hatching singing is "later at night" (Reynolds and Linkhart 1987).

Surveys should only be conducted under favorable conditions: wind speeds <20 km per hour, a wind speed of Beaufort 3 or less and no precipitation (including rain and/or snow). Temperatures should be close to the average for the season and efforts should be made to avoid extremely cold temperatures because of evidence that owls may be less vocal in very cold weather (Takats 1998a).

Surveys will consist of visiting a point for two minutes to listen for Flammulated Owls calling, and if no owls are heard then a male territorial call will be imitated or played from tape for one minute. After listening for an additional two minutes, the observer will then walk to the next point while still listening for calling owls. (Two minutes appears to be adequate for most spontaneously calling owls to be detected, at least during the period of peak calling activity. In Alberta, relatively few additional owls were detected during a third minute of listening (Takats, pers. comm.). In Ontario, more than 70% of 5 species of owls that were detected over a 5 minute period (included playback) were detected in the first two minutes (Takats 1997, 1998b)

Playback recordings should be as clear and loud as possible without distortion. Digital technology is recommended (CD-ROM, solid state, or digital tape) as the sound quality can be better controlled and is less likely to deteriorate over time. The audio equipment should be of sufficient quality that it will not distort the sound at loud volumes. We suggest the volume be such that the recording can be heard at 400m, but not at 800m (to minimize bias at the next survey station due to owls hearing the recording from the previous station). If possible, the volume should be measured at a standard distance (e.g., 1m from the speakers) using a decibel meter.

The recording should include both the silent listening periods as well as the playback sequence time period. A soft ‘beep’ or other sound can be used to indicate the start of the first silent listening period, and another beep to indicate the end of the final listening period. This will ensure that the time is fully standardized at each station, and reduce the need for participants to keep checking their watches.

Surveyors should be asked to estimate the approximate direction and distance to the first position where they detect each owl and plot location on a map. This data can help to determine whether the same owls are being detected at different stations along the route, to adjust for some of the variation in detection rates, and to aid in daytime nest searches.

Male presence is not adequate to determine habitat suitability as many males may remain unmated (Reynolds and Linkart 1987a, McCallum 1994a). The nests should be monitored so that success can be determined. Parallel transects 50 m apart through areas where owls were detected were surveyed in June and early July to try and find nest site locations. Since most of the calls heard in the field are from territorial reproductive males, nests can be located by systematic nest searches during the day (Bull et al. 1990). Once territory boundaries are delineated, all suitable nesting cavities (tree cavities with entrance diameters >4 cm) within territories will be checked for nesting owls (Linkart and Reynolds 1997).

Nest sites will be searched for using a pinhole camera system attached to a telescoping pole that reaches approximately 11 m high (Proudfoot 1996). This is an effective nest finding technique, but is limited to cavities within reach. Tree scratching (with a stick) can also used, which imitates a predator climbing the nest tree and often stimulates incubating or brooding females to look out of the nest cavity entrance (Bull et al. 1990). Observation of a female Flammulated Owl at a cavity entrance will document a nest site.

Analysis: Data from the surveys described here are similar to those of the Breeding Bird Survey, though some modifications may be required in the future. A wide variety of methods have been developed for analysis of BBS data (James et al. 1996, Link and Sauer 1994, 1998), but there is still some disagreement as to which methods are best (James et al. 1996, Link and Sauer 1994a, Link and Sauer 1994b, Thomas 1996). There are two main methods currently being used by the coordinators of the BBS. One involves route regression using estimating equations (Link and Sauer 1994), which assumes that trends may differ among routes, and calculates a weighted mean of the trends within routes. The selection of weighting factors is strongly dependent upon the sampling scheme used to select routes. An alternate approach involves a generalized linear model assuming over-dispersed Poisson residuals and a log-link function (Link and Sauer 1998). This approach assumes that trends are similar within a broader region, and allows more robust modeling of nonlinear population changes (e.g., year to year fluctuations). A simplified version of this latter approach has been used for analysis of population trends in Ontario (Lepage et al 1999, Francis and Whittam 2000), but it is not yet known whether this is the most appropriate analysis method.

The power of the survey technique will be investigated after its first three years in its present design to determine the actual variance. This will allow us to determine the number of routes required to detect our objective of a 35% change by 2020.

Finally, we recommend that relevant data be made publicly available, preferably over the Internet. This will encourage further research into analysis methods, thus ensuring that maximum use is made of the data for conservation purposes. However, care should be taken to protect sensitive information, such as precise nesting locations of rare species.

White-headed woodpecker

Rationale: Suitable white-headed woodpecker habitat includes large patches (greater than 350 acres) of open mature/old growth ponderosa pine stands with canopy closures between 10 - 50 percent and snags (a partially collapsed, dead tree) and stumps for nesting (nesting stumps and snags greater than 31 inches DBH). Maintaining white-headed woodpecker populations will require that this mature/old growth component of ponderosa pine habitat is maintained or enhanced within the subbasin.

Limiting Factors: 1) Silvicultural practices that reduce habitat quality; 2) pesticide use; 3) predation/competitors; 4) exotics.

Assumptions: If ponderosa pine habitat is of sufficient quality, extent, and distribution to support viable white-headed woodpecker populations, the needs of most other ponderosa pine obligate species will also be addressed and ponderosa pine functionality could be inferred.

Sampling Strategy: Survey points will be placed among habitat types of interest using a stratified random design. Number of survey points in each habitat type will be determined using power analysis with the goal of being able to detect a 25% increase in abundance of white-headed woodpecker with a power of 0.8 or greater.

Methods: The method used, point counts, is derived from Dixon (1998)

POINT COUNTS

Each observer will conduct one transect per day individually. Survey low-elevation transects first to assure accessibility. The protocol for point counts will follow standardized methods for variable circular plots (Reynolds et al. 1980, Ralph et al.1995, Hutto and Hoffland 1996), but modified to better census White-headed Woodpeckers.

WHEN TO SURVEY: Point counts should be conducted between April 1 and May 15 when the detectability of White-headed Woodpeckers is highest and most stable. After this period the woodpeckers typically excavate from within the nest cavity and become less visible and less vocal. Counts should begin at official sunrise and end no later than 1030 and 1100. Each transect will be visited once.

POINT COUNTS: Counts will begin as soon as the observer arrives at the station and will be comprised of a 5-minute listening period without the use of tape playbacks followed by a 6-minute sequence of tape playbacks of White-headed Woodpecker calls and drums for a total count of 11 minutes. Data from the two types of counts will be recorded separately-with a code-on a the bird data sheet.

TAPE PLAYBACK PROCEDURE: Tape playback procedures will essentially follow the Payette National Forest Protocol for Broadcast Vocalizations (Payette National Forest 1993). The tape playback sequence should begin immediately after the 5-min unsolicited point count-be ready to start the tape at exactly 5 min. A total of four 30-second tape-playbacks of White-headed Woodpecker drums and calls will be projected at 1-min intervals (e.g. using a Johnny Stewart™ game caller); that is, begin the first sequence of vocalizations to the north. During the one minute pause after the first sequence, rotate 90° for the second sequence, pause, then rotate another 90° for the third sequence of vocalizations after the second one minute break. When the third sequence is complete, rotate 90° for the fourth and final sequence for a total of 6 minutes of tape-playbacks.

WHEN NOT TO SURVEY: Surveys will not be conducted during heavy rain, fog, or when wind interferes with an observer's ability to detect calls (greater than 20 mph). If the weather appears prohibitive, wait 1 to 1.5 hours, or until you cannot reasonably complete the transect by 1100 hours. If the weather puts you in danger, STOP-your safety comes first.

WHAT TO RECORD: Record all species detected, visual or auditory. At the bottom of the data sheet, record any birds you might have detected either before or after a point count, or between stations.

Pygmy nuthatch

Rationale: Suitable pygmy nuthatch habitat contains heterogeneous stands of ponderosa pine with a mixture of well-spaced, old pines and vigorous trees of intermediate age. Pygmy nuthatch represents those species that depend on snags for nesting and roosting, high canopy density, and large diameter (greater than 18 inches DBH) trees characteristic of mature undisturbed forests. Connectivity between suitable habitats is important for species, such as pygmy nuthatch, whose movement and dispersal patterns are limited to their natal territories.

Limiting Factors: 1) Silvicultural practices that reduce habitat quality; 2) fragmentation; 3) predation/competitors; 4) exotics.

Assumptions: If ponderosa pine habitat is of sufficient quality, extent, and distribution to support viable pygmy nuthatch populations, the needs of most other ponderosa pine obligate species will also be addressed and ponderosa pine functionality could be inferred.

Sampling Strategy: This is a survey development need.

7.8.9 Shrubsteppe

Focal Species

Brewer's sparrow (Spizella breweri), mule deer (Odocoileus hemionus hemionus)

Overall Habitat and Species Monitoring Strategy: Establish monitoring program for protected and managed shrubsteppe sites to monitor focal species population and habitat changes and evaluate success of efforts.

Focal Habitat Monitoring

Factors affecting habitat:

1. Direct loss shrubsteppe due to conversion to agriculture, residential, urban and recreation developments
2. Fragmentation of remaining shrubsteppe habitat, with resultant increase in nest parasites
3. Fire Management, either suppression or over-use, and wildfires
4. Invasion of exotic vegetation
5. Habitat degradation due to overgrazing, and invasion of exotic plant species
6. Loss and reduction of cryptogamic crusts, which help maintain the ecological integrity of shrubsteppe/grassland communities.

Shrub-steppe Working Hypothesis Statement: The near term or major factors affecting this focal habitat type are direct loss of habitat due primarily to conversion to agriculture, reduction of habitat diversity and function resulting from invasion of exotic vegetation and wildfires, and livestock grazing. The principal habitat diversity stressor is the spread and proliferation of annual grasses and noxious weeds such as cheatgrass and knapweeds that either supplant and/or radically alter entire native bunchgrass communities significantly reducing wildlife habitat quality. Habitat loss and fragmentation (including fragmentation resulting from extensive areas of undesirable vegetation) coupled with poor habitat quality of extant vegetation have resulted in extirpation and/or significant reductions in shrub-steppe obligate wildlife species.

Recommended Range of Management Conditions

Condition 1: Sagebrush dominated shrubsteppe: The Brewer's sparrow was selected to represent wildlife species that require sagebrush dominated sites, but prefer a patchy distribution of sagebrush clumps 10-30 percent cover, lower sagebrush height (between 20 and 28 inches), native grass cover 10 to 20 percent (Dobler 1994), non-native herbaceous cover less than 10 percent, and bare ground greater than 20 percent (Altman and Holmes 2000).

Condition 2 - Diverse shrubsteppe habitat: Mule deer were selected to represent species that require/prefer diverse, dense (30 to 60 percent shrub cover less than 5 feet tall) shrubsteppe habitats comprised of bitterbrush, big sagebrush, rabbitbrush, and other shrub species (Leckenby 1969; Kufeld et al. 1973; Sheehy 1975; Jackson 1990; Ashley et al. 1999) with a palatable herbaceous understory exceeding 30 percent cover (Ashley et al. 1999).

Focal Habitat Monitoring Strategies

Establish an inventory and long-term monitoring program for protected and managed shrubsteppe habitats to determine success of management strategies. Subbasin managers recognize that restoration of shrubsteppe is still very much a fledgling field, and complete restoration of degraded or converted shrubsteppe may not be feasible. These monitoring strategies reflect the commitment to and initiation of the process of longterm management.

1. Identify shrubsteppe habitat sites within the subbasin that support populations of Brewer's sparrow
2. Evaluate habitat site potential on existing public lands and adjacent private lands for protection of focal species habitat (short-term strategy i.e., < 2 years).
3. Enhance habitat on public lands and adjacent private lands (intermediate strategy; 2 to 10 years)
4. Identify high quality/functional privately owned shrubsteppe sites that are not adjacent to public lands (long-term strategy 2 to 15 years).
5. Establish permanent censusing stations to monitor bird population and habitat changes.

Sampling Design: Permanent survey transects will be located within shrubsteppe habitats using HEP protocols. HEP is a standardized habitat-analysis strategy developed by the U.S. Fish and Wildlife Service. It uses a variety of Habitat Suitability Indices (HSI) for select wildlife species to evaluate the plant community as a whole (Anderson and Gutzwiller 1996). Sites are stratified by cover type, and starting points are established using a random number grid. Minimum length of a HEP transect is 600 ft, and patches of cover must be large enough to contain a minimum transect without extending past a 100 foot buffer inside the edge of the cover type.

In addition, at any permanently established avian species monitoring site established within the Shrubsteppe habitat, structural habitat conditions will be monitored every 5 years as per Habitat Structure Assessment protocol (Nott et al 2003).

Sampling Methods (USFWS 1980a and 1980b):

1. Bare ground or cryptogram crust measurements are taken every 20 ft. on the right side of the tape (the right is always determined by standing at 0 ft and facing the line of travel). The sampling quadrant is a rectangular 0.5m2 microplot, placed with the long axis perpendicular to the tape, and the lower right corner on the sampling interval.

The percentage of the microplot consisting of either bare ground or cryptogram crust is estimated via ocular estimate.

2. Herbaceous measurements are taken every 20 ft. on the right side of the tape (the right is always determined by standing at 0 ft and facing the line of travel). The sampling quadrant is a rectangular 0.5m2 microplot, placed with the long axis perpendicular to the tape, and the lower right corner on the sampling interval.

Herbaceous cover % is measured via an ocular estimate of the percentage of the microplot shaded by any grass or forb species.

3. Shrub canopy cover is measured using a point intercept method and is visually estimated before starting each transect. If the total shrub cover is anticipated to be >20%, shrub data are collected every 5 ft (20 possible "hits" per 100 ft segment). If shrub canopy cover is anticipated to be <20%, data are collected every 2 ft (50 possible "hits" per 100 ft segment).

Shrub canopy cover is measured on a line intercept 'hit' or 'miss'. Measurements are taken every 2 or 5 feet, depending upon shrub density.

Shrub height measurements are collected on the tallest part of a shrub that crosses directly above each sampling intercept mark. For shorter shrub classifications (i.e. all shrubs less than 3 feet), the tallest shrub is measured that falls within that category.

4. Tree canopy cover measurements are taken every ten feet along a transect. Basal and snag measurements are taken within a tenth-acre circular plot at the end of each 100 ft segment. The center point of the circular plot is the 100 ft mark of the transect tape, and the radius of the circle is 37.2 ft.

Analysis: Transects are divided into 100 ft. segments, and total transect length is determined using a "running mean" to estimate variance (95% probability of being within 10% of the true mean).

Sample size equation: n = t2 x s2

E2

Where: t = value at 95 percent confidence interval with suitable degrees of

freedom

s = standard deviation

E = desired level of precision, or bounds

Focal Species Monitoring

Brewer's Sparrow

Rationale: The main premise for focal species selection is that the requirements of a demanding species assemblage such as Brewer's sparrow encapsulate those of many co-occurring less demanding species. By directing management efforts toward the requirements of the most exigent species, the requirements of many cohabitants that use the same habitat type are met. Therefore, managing habitat conditions for a species assemblage comprised of these three species should provide life requisite needs for most other shrubsteppe obligate species.

Limiting Factors: 1) Conversion of native shrub-steppe habitat for agricultural purposes, 2) habitat fragmentation; 3) degradation of existing habitats from overgrazing and introduced weedy vegetation, 4) brush removal, 5.) wildfire

Assumptions: 1) Addressing factors that affect shrub steppe habitat will address Brewer's sparrow; 2) If shrub steppe habitat is of sufficient quality, extent, and distribution to support Brewer's sparrow populations, the needs of most other shrub steppe obligate species will also be addressed and shrub steppe functionality could be inferred.

Sampling Strategy: Survey points will be placed among habitat types of interest using a stratified random design. Number of survey points in each habitat type will be determined using power analysis with the goal of being able to detect a 35% increase in abundance of key species with a power of 0.8 or greater.

Methods: We will survey birds on 64 sites in different vegetation types and levels of fragmentation. Each site will have 4 100-m fixed-radius point counts (Ralph et al. 1993) established along a transect and spaced 200m apart (Fig 4). The outer points of the point-count circles will describe a rectangular plot of 16ha that will be the focus of all survey work in Objectives 2-4. Each point will be marked with a permanent fiberglass stake (1m electric fence post) and colored flagging will be placed on shrubs at 50 and 100m from the point in each of the 4 cardinal directions to aid in determining distance. Counts at each point will be 5 minutes in duration during which all birds seen or heard will be noted, along with their sex (if known), distance from the point (within 50m, >50 but <100m, or beyond 100m), and behavior (singing, calling, silent, or flying over the site). Surveys will be conducted once each in May and June and within prescribed weather parameters (e.g., no rain and low wind).

Mule Deer

Rationale: Mule deer inhabit all habitats within the subbasin. The largest concentration of mule deer is found in the lower Entiat basin during winter. Shrub-steppe habitat quality determines the size and persistence of mule deer populations within the subbasin, as they are both critical winter habitat and the limiting factor for this species in the subbasin. Mule deer have been selected as a focal species due to the significant economic, recreational, and cultural values this species provides.

Limiting Factors: 1) flooding of habitat resulting from hydropower facilities, 2) loss of habitat due to urban and suburban development, 3) road and highway construction, 4) degradation of existing habitats from overgrazing and introduced weedy vegetation, 5) alteration of historic fire regimes, 6) past silvicultural practices, 7) deer control efforts necessitated by agricultural damage, 8) natural predation and over-harvest by hunters, 9) disease and parasites

Assumptions: Addressing factors that affect shrubsteppe habitats, will also address mule deer and other shrubsteppe obligate species limiting factors.

Management Objective: The population management objective for mule deer will be to increase or maintain populations within the limitations of available mule deer habitat and landowner tolerance (agricultural damage). Population monitoring variables and objectives are established in the Washington Department of Fish and Wildlife Game

Management Plan (WDFW 2003). In areas with periodically high mule deer populations and significant agricultural damage complaints, WDFW will regulate populations as appropriate through hunter harvest.

Monitoring Methods: Mule deer populations will be monitored using a combination of post hunting surveys, spring surveys and harvest data. Current surveys allow the monitoring of age/sex ratios to determine if management objectives established in the Game Management Plan (WDFW 2003) are being met for post-season buck survival (> 15 bucks/100 does) and fawn production and recruitment. Harvest data is used as an indicator of population trend.

Evaluation Strategies:

1. Use winter aerial and ground surveys to classify mule deer to determine post-hunt buck/fawn to doe ratios, spring fawn to adult ratios, and population size trends.
2. Monitor harvest level of bucks and antlerless deer using mandatory hunter report system.
3. Model the Chelan PMU mule deer population (which extends beyond the subbasin border).

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9 Acronyms and Abbreviations

ACOE	US Army Corps of Engineers
AF	acre feet
AFWP	Agriculture Fish and Wildlife Program
BLM	Bureau of Land Management
BPA	Bonneville Power Administration
BOR	Bureau of Reclamation
BiOP	biological opinion
BRT	biological review team
CAA	Clean Air Act
CBFWA	Columbia Basin Fish and Wildlife Authority
CCCD	Chelan County Conservation District
CCD	County Conservation District
CCP	Columbia Cascade Province
CCRP	Continuous Conservation Reserve Program
cfs	cubic feet per second
Colville Tribes	Confederated Tribes of the Colville Reservation
CP	cover practices
CREP	Conservation Reserve Enhancement Program
CRITFC	Columbia River Inter-Tribal Fish Commission
CRMP	Coordinated Resource Management Plan
CRP	Conservation Reserve Program
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DBH	diameter at breast height
DEIS	Draft Environmental Impact Statement
DOI	US Department of the Interior
DPS	distinct population segment
EA	Environmental Assessment

EDT	Ecosystem Diagnostic & Treatment
EIS	Environmental Impact Statement
EPA	US Environmental Protection Agency
EQUIP	Environmental Quality Incentives Program
ESA	Endangered Species Act
ESU	Ecologically Sensitive Unit
EWPU	Entiat WRIA Planning Unit
FEIS	Final Environmental Impact Statement
FERC	Federal Energy Regulatory Commission
FCRPS	Federal Columbia River Power System
FIP	Forest Incentive Program
FLIR	forward looking infrared
FLPMA	Federal Land Policy and Management Act
FSA	Farm Services Administration
GAP	Gap Analysis Program
GCFMP	Grand Coulee Fish Management Plan
GCDFMP	Grand Coulee Dan Fish Maintenance Project
gpm	gallons per minute
GIS	Geographic Information System
GMA	Growth Management Act
HGMP	Hatchery Genetic Management Plan
IBIS	Interactive Biological Information System
ICBEMP	Interior Columbia Basin Ecosystem Mgmt. Project
ICBTRT	Interior Columbia Basin Technical Recovery Team
ISG	Independent Scientific Group
ISRP	Independent Scientific Review Panel
LFA	limiting factors analysis
LSC	Landowner Steering Committee
LWD	large woody debris
MCMCP	Mid-Columbia Mainstem Conservation Plan

MPRSA	Marine Protection, Research and Sanctuaries Act
MYS	maximum sustained yield
NEPA	National Environmental Policy Act
NGO	Non-governmental Organization
NF	National Forest
NFMA	National Forest Management Act
NFN	National Fish Hatchery
NFS	National Forest System
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPCC	Northwest Power and Conservation Council
NPPC	Northwest Power Planning Council
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
PHS	priority habitats and species
PPA	Pollution Prevention Act
PUD	Public Utility District
RD	Ranger District
RM	river mile
RMP	Resource Management Plan
ROD	Record of Decision
RTT	Regional Technical Team
SASSI	Washington State Salmon and Steelhead Stock Inventory
SOR	systems operation review
SRMA	Salmon Recovery Management Act
TAC	Technical Advisory Committee
TMDL	total maximum daily load
TRT	Technical Recovery Team

Upper Columbia RUT	Upper Columbia Recovery Unit Team
USDA	United States Department of Agriculture
USDOE	United States Department of Energy
USDI	United States Department of Interior
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VOR	visual obstruction readings
WAC	Washington Administrative Code
WDNR	Washington Department of Natural Resources
WCC	Washington Conservation Commission
WDOE	Washington Department of Ecology
WDF	Washington Department of Fisheries
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WDOE	Washington Department of Ecology
WDW	Washington Department of Wildlife
WHIP	Wildlife Habitat Improvement Program
WQI	water quality index
WPA	Watershed Planning Act
WRIA	Water Resource Inventory Area
WRP	Wetlands Reserve Program
Yakama Nation	Confederated Tribes and Bands of the Yakama Nation

10 Appendices

Appendix A. Ashley and Stovall. 2004. Entiat Wildlife Assessment. WDFW. Olympia, Washington

Appendix B. Hillman et al. 2004. Monitoring Strategy for the Upper Columbia Basin. BioAnalysts, Inc. Eagle, Idaho

Appendix C. BioAnalysts. April 2004. Effects of Hydroelectric Dams on Viability of Wild Fish.

Appendix D. Summary of Artificial Production in the Entiat Subbasin

Appendix E. Peven et al. 2004. Hatchery Information for Subbasin Planning